DOCUMENT RESUME

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TITLE	Steelworker--Gas Welding, 3-24. Military Curriculum Materials for Vocational and Technical Education.
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SPONS AGENCY	Office of Education (DHEW), Washington, D.C.
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DESCRIPTORS	Behavioral Objectives; Blueprints; Course Descriptions; Curriculum Guides; Learning Activities; Lesson Plans; *Metal Working; Postsecondary Education; Secondary Education; Skilled Occupations; Textbooks; *Trade and Industrial Education; *Welding
IDENTIFIERS	*Brazing; Military Curriculum Project; *Soldering

ABSTRACT

This teacher guide, student materials, and text for a secondary-postsecondary level course for steelworker gas welding and cutting comprise one of a number of military-developed curriculum packages selected for adaptation to vocational instruction and curriculum development in a civilian setting. The purpose stated for the course is to provide students with competency in blueprint reading, welding, brazing, and soldering. Some previous experience with welding and cutting is required before enrollment is permitted. The course contains 56 hours of classroom and shop instruction divided into three phases: (1) blueprint reading, welding electrodes, rods, welding aids, annealing, hardening, and tempering; (2) gas welding pipe (vertical and horizontal positions), general brazing, and soldering; and (3) silver brazing. The instructor guide provides an introduction to the course; outline of instruction; outline of training activities; and lists of texts, references, tools, equipment, material, training aids, training aids equipment, and master schedule. The outline of instruction contains the lesson plan along with teacher and student activities. Student job sheets and information sheets are provided. Text materials cover blueprint reading, layout and fabrication, and soldering. Six military manuals, one commercial text, and three films are suggested as texts, references, or support material. (YLB)

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MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

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- Evaluating individual program needs and outcomes
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- Operating information systems and services
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Military Curriculum Materials
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Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

NORTHWEST
William Daniels
Director
Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

SOUTHEAST
James F. Shill, Ph.D.
Director
Mississippi State University
Drawer DX
Mississippi State, MS 39762
601/325-2510

NORTHEAST
Joseph F. Kelly, Ph.D.
Director
225 West State Street
Trenton, NJ 08625
609/292-6562

WESTERN
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

STEELWORKER GAS WELDING AND CUTTING

Table of Contents

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Steeelworker 615.2 Gas Welding And Cutting - Instructor Guides And Supporting Material Page 3

Blueprint Reading And Sketching

Chapter 1 - Blue Prints Page 159

Chapter 5 - Sheet Metal Layout And Fabrication Page 172

Chapter 6 - Plate And Pipe Layout And Fabrication Page 181

Chapter 13 - Soldering Page 204

Chapter 18 - Reinforcing Steel Page 213

STEELWORKER, GAS WELDING AND CUTTING

Classroom Course 3-24

Developed by:

United States Navy

Development and Review Dates

No date

D.O.T. No.:
680.281

Occupational Area:
Building and Construction

Target Audiences:
Grades 10-adult

Print Pages:
125

Cost:
$2.50

Availability:
Military Curriculum Project, The Center for Vocational Education, 1960 Kenny Rd., Columbus, OH 43210

Contents:	Type of Materials:						Instructional Design:				Type of Instruction:	
	Lesson Plans:	Programmed Text:	Student Workbook:	Handouts:	Text Materials:	Audio-Visuals:	Performance Objectives:	Tests:	Review Exercises:	Additional Materials Required:	Group Instruction:	Individualized:
Phase 1												
1.1.1 Blueprint Reading	●				●	★	●	●			●	●
1.1.2 Welding Electrodes, Rods and Welding Aids	●						●	●		★	●	
1.2.1 Annealing, Hardening and Tempering	●						●	●		★	●	●
Phase 2												
2.1.1 Gas Welding Pipes, Vertical Position	●			●			●	●		★	●	●
2.1.2 Evaluation of Gas Welding Pipe-Vertical	●						●	●		★		●
2.1.3 Welding Pipe, Horizontal-Position	●						●	●		★		●
2.1.4 Evaluation of Gas Welding-Horizontal	●						●	●		★		●
2.2.1 General Blazing	●						●	●		★	●	●
2.2.2 Soldering	●				●	★	●	●		★	●	●
Phase 3												
3.1.1 Silver Brazing (steel)	●						●	●		★	●	●
3.1.2 Silver Brazing (brass)	●						●	●		★		●
3.1.3 Silver Brazing (stainless)	●						●	●		★		●

★ Materials are recommended but not provided.

Course Description:

After completing this short course, students will be competent in reading simple blueprints from shopwork; identifying welding consumables; defining and knowing purposes for annealing, hardening, and tempering; using correct techniques in preparation of welding pipe in vertical fixed position and horizontal fixed position; performing general brazing and soldering; and doing silver brazing. Some previous experience with welding and cutting is required for this course. This course contains fifty-six hours of classroom and shop instruction divided into three phases.

Phase 1 contains two units totaling ten hours of classroom and nine hours of shop instruction.

Unit 1

1.1.1 – Blueprint Reading (2 hours classroom, 7 hours shop)
1.1.2 – Welding Electrodes, Rods and Welding Aids (5 hours classroom)

Unit 2

1.2.1 – Annealing, Hardening and Tempering (3 hours classroom, 2 hours shop)

Phase 2 contains two units totaling three hours classroom, and twenty-three hours of shop instruction:

Unit 1

2.1.1 – Gas Welding Pipes, Vertical Position (1 hour classroom, 5 hours shop)
2.1.2 – Evaluation of Gas Welding Pipe—Vertical (2 hours shop)
2.1.3 – Gas Welding Pipe, Horizontal Position (5 hours shop)
2.1.4 – Evaluation of Gas Welding Pipe-Horizontal (2 hours shop)

Unit 2

2.2.1 – General Brazing (1 hour classroom, 5 hours shop)
2.2.2 – Soldering (1 hour classroom, 4 hours shop)

Phase 3 contains one unit with one hour of classroom and ten hours of shop instruction:

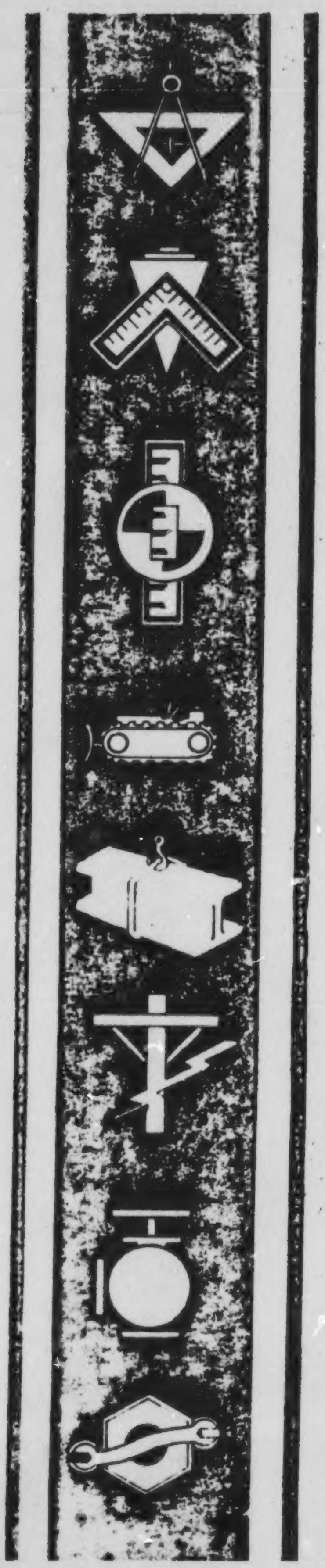
Unit 1

3.1.1 – Silver Brazing (steel) (1 hour classroom, 3 hours shop)
3.1.2 – Silver Brazing (brass) (3 hours shop)
3.1.3 – Silver Brazing (stainless) (4 hours shop)

The course contains both instructor and student materials. The instructor guide contains an introduction to the course; an outline of instruction; an outline of training objectives; and lists of texts, references, tools, equipment, materials, training aids, training aids equipment and the master schedule. The outline of instruction contains the lesson plan along with teacher and student activities. Student job sheets and information sheets are also provided.

The text materials provided for this course are taken from two Navy manuals, *Blueprint Reading and Sketching, NAVPERS 10077-C* and *Steelworker 3&2, NAVPERS 10653*. One additional military manual and one commercial text are also suggested. Five military manuals are suggested for use as references. The following films are listed as support material but are not provided:

MN-37	Behind the Shop Drawing
MN-4831-I	The Use of Soldering Coppers
MC-679A	Engineering Drawing-Orthographic Projection



NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA
93043

STEELWORKER
SEABEE TECHNICAL TRAINING COURSE
615.2 GAS WELDING AND CUTTING

DEPARTMENT OF THE NAVY ★ NAVAL SCHOOLS, CONSTRUCTION

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TITLE: Steelworker- Gas Cutting and Welding II.

Course Number; Special Technical Training Course 615.2

Course Length: 56 periods - 51 hours contact time

Taught at: Naval Schools Construction, Port Hueneme, Naval Schools Construction, Davisville, Rhode Island; Construction Training Unit, Gulfport, Mississippi.

Class capacity: Max 10
Min 6

Instructor Requirements per class : 2

Course Cirriculum Model Manager: Naval Schools, Construction, Port Hueneme, Calif. 93043

Quota Management Authority: School at which taught

Quota Control: School at which taught

Approval/Implementation Date: When approved by the Chief of Naval Technical Training.

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COURSE DATA PAGE

Course Mission: To train selected steelworkers in the knowledge and skill factors defined by the Personnel Readiness and Capability Program for Steelworkers skill.

Personnel and Rating Eligible: E3 through E6

Obligated service: None

NOBC/NEC Earned: None

Physical Requirements: No special requirements

Security clearance Required: None

Prerequisite Training and/or Basic Battery Test score required: Gas Cutting/ Welding I - 615.1

Related Training: Maintenance Welding

Follow on training: Arc Welding-structural I- 610.1

EVALUATION: Unless otherwise specified, performance will be evaluated on a GO/NO GO basis.

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HOW TO USE INSTRUCTOR GUIDES

Instructor Guides are provided for each topic and include supporting instructional materials and aids identified by the topic number and preceded by a letter code designation. The letter code key is as follows:

AS - Assignment Sheet
JS - Job Sheet
IS - Information Sheet
CN - Class Notes
OS - Operation Sheet
T - Test
FT - Final Test
TR - Transperencies
DS - Diagram Sheet
PS - Problem Sheet
PT - Pretest
PE - Performance Evaluation
WS - Work Sheet
C - General (give a definition of item)

A complete listing of all supporting materials and aids is documented with full descriptive titles in Annex.

The instructor guides ar intended to be used as master lesson plans subject to personalization by the individual instructor. In all cases, it is expected that the instructor will study the references in prepartation for annotating the guide. It is also expected that each instructor will develop an appropriated introduction for each topic that will (1) create interest, (2) show the value of the topic to the student, (3) relate the topic to previous and future topics in the course, and (4) communicate the learning objectives to the student. Well prepared introductions will then provide the important motivational conditioning to establish readiness and effect for learning appropriate to each topic.

The first page of each instructor guide contains the following functional information:

1. Topic of lesson
2. Time in periods
3. References
4. Instructional Aids
5. Instruction Aids
6. Objectives
7. Topic criterion test (as applicable)
8. Homework assignment (when applicable)
9. Tools and materials

The pages following page 1 of each instructor guide provide in a three-column format the teachin/learning procedures for conducting the lesson. The left hand column includes the outline of instructional content required by the objectives: the center column includes recommended instructor activities or methodology, the right hand column contains recommended student learning activities.

While the methodology and student learning activities documented in each instructor guide have been tested and proven to be effective for the lead school, those schools implementing this curriculum are encouraged to exercise creativity in designing learning exercises and conceiving methods and techniques to meet course objectives.

OUTLINE OF TRAINING OBJECTIVES
STEELWORKER SCHOOL

SPECIAL TECHNICAL TRAINING
GAS CUTTING/WELDING II

	Class	Pract	Total
PHASE 1 UNIT 1			
1.1.1 Blueprint Reading	2	7	9
1.1.2 Welding Electrodes, Rods and Welding Aids	5		5
UNIT 2			
1.2.1 Annealing, Hardening and Tempering	3	2	5
PHASE 2 UNIT 1			
2.1.1 Gas Welding Pipes, Vertical Position	1	5	6
2.1.2 Evaluation of Gas Welding Pipe - Vertical		2	2
2.1.3 Gas Welding Pipe, Horizontal Position		5	5
2.1.4 Evaluation of Gas Welding Pipe-Horizontal		2	2
UNIT 2			
2.2.1 General Brazing	1	5	6
2.2.2 Soldering	1	4	5
PHASE 3 UNIT 1			
3.1.1 Silver Brazing (steel)	1	3	4
3.1.2 Silver Brazing (brass)		3	3
3.1.3 Silver Brazing (stainless)		4	4

Total Perids, Class	14	22%
Total Periods, Practical	42	78%
Total Periods, Course	56	
Total Weeks for Course	2	

TRAINING OBJECTIVES

PHASE 1

UNIT 1

Upon completion of this unit the student will have: Read simple prints for shop work: identified title box and read notes and specification as found on simple prints: All must be within 100% accuracy. Identified the welding consumables in the Mobile Construction Battalion Table of Allowance, namely arc welding electrodes, gas welding rods, wearfacing electrodes and welding aids: stated their primary use and secondary use when applicable without error.

1.1.1. Topic: Blueprint Reading
Upon completion of this topic the student will have:

A. Read simple prints for shop work; Identified title box and read notes and specifications as found on simple prints. All must be within 100% accuracy.

1.1.2 Topic: Welding Electrodes, Rods and Welding Aids:
Upon completion of this topic the student will have:

A. Identified the welding consumablies in the Mobile Construction Battalion Table of Allowance, namely arc welding electrodes, gas welding rods, wearfacing electrodes and welding aids: Stated their primary use and secondary use when applicable without error.

UNIT 2

Upon completion of this unit the student will have: Defined the term anneal and listed four purposes of the process; Defined hardening in terms of work, flame and case hardening; stated the definition of tempering and its purpose. All will be without error.

1.2.1 Topic: Annealing, Hardening and Tempering
Upon completion of this topic the student will have:

A. Defined the term anneal and list four purposes of the process

B. Defined hardening in terms of work, flame and case hardening.

C. Stated the definition of tempering and its purpose.

D. All the above will be done without error.

PHASE 2

UNIT 1

Upon completion of this unit the student will have: Performed correct techniques for welding pipe as to gage setting, type of flame, speed of travel manipulation of torch and correct welding rod. Perform specified degree of cleaning of completed weld. Demonstrate proper pipe preparation by beveling, cleaning, aligning, spacing and tack welding priop to welding. Gas weld with a 1/8" triple deoxidized rod V butt joints in the vertical and horizontal fixed positions a 2" mild steel pipe. In doing this he will apply all pertinent safety precautions as stripulated in IS - 1.1.1.1 and identify and apply the correct procedures and methods of correcting faults. Evaluation will be based on the Qualification Test for AR-3 level of American Welding Society, standard for Qualification of Welding Procedures and Welders of Piping and tubing, AWS d10. 9-72 condensed in standard STT-FT-1 attached to this unit. The final weld must meet the minimum requirements established for gas welding pipe in the vertical and horizontal fixed non-restricted position, listed in STT-FT-1.

2.1.1 Topic: Gas Welding Pipe, Vertical Position
Upon completion of this topic the student will have:

A. Performed correct techniques for welding pipe as to gage setting, type of flame, speed of travel, manipulation of torch and correct welding rod. Performed specified degree of cleaning of completed weld.

B. Demonstrated proper pipe preparation by beveling, cleaning, aligning, spacing and tack welding, prior to welding.

C. Gas weld with a 1/8" triple deoxidized rod a V-butt joint in the vertical fixed position a 2" mild steel pipe. In doing this he will apply all pertinent safety precautions as tipulated in IS-1.1.1.1. and identify and apply the correct procedures and methods of correcting faults. Evaluation will be based on the Qualification Test for AR-3 level of American Welding Society, Standard for Qualification of Welding Procedures and Welders for Piping and tubing, AWSD10.9-72 condensed in standard STT-FT-1 attached to this unit.

2.1.2 Topic: Practical Evaluation in Gas Welding Pipe, Vertical fixed position.
Upon completion of this topic the student will have:

A. Performed correct techniques for welding pipe as to gage setting, type of flame, speed of travel, manipulation to torch and correct welding rod. Perform specified degree of cleaning of completed weld.

B. Demonstrated proper pipe preparation by beveling, cleaning, aligning, spacing and tack welding prior to welding.

C. Gas welded a 1/8" triple deoxidized rod a V-butt joint in the vertical fixed position a 2" mild steel pipe. In doing this he will apply all pertinent safety precautions as stipulated in IS-1.1.1.1 and identify and apply the correct procedures and methods of correcting faults. Evaluation will be based on the Qualification Test for Qualification of Welding Procedures and Welders for Piping and Tubing, AWS D-10. 9-72 condensed in standard STT-FT-1 attached to this unit. The final weld must meet the minimum requirements established for gas welding pipe in the vertical fixed non-restricted position.

2.1.3 Topic: Gas Welding Pipe, Horizontal Fixed Position
Upon completion of this topic the student will have:

A. Performed correct techniques for welding pipe as to gage setting, type of flame, speed of travel, manipulation of torch and correct welding rod. Perform specified degree of cleaning of completed weld.

B. Demonstrate proper pipe preparation by beveling, cleaning, aligning spacing, and torch welding, prior to welding.

C. Gas weld with a 1/8" triple deoxidized rod, a V-butt joint in the horizontal fixed position a 2" mild steel pipe. In doing this he will apply all pertinent safety precautions as stipulated in IS.1.1.1.1 and indentify and apply the correct procedures and methods of correcting faults. Evaluation will be based on the Qualification Test for AR-3 level of American Welding Society, Standard for Qualification of Welding Procedures and Welders for Piping and Tubing, AWS-D-10-9-72 condensed in standard STT-FT-1 attached to this unit.

2.1.4 Topic: Practical Evaluation in Gas Welding Pipe, Horizontal Fixed Position
Upon completion of this topic the student will be able to:

A. Perform correct techniques for welding pipe as to gage setting, type of flame, speed of travel, manipulation of torch and correct welding rod. Perform specified degree of cleaning of completed weld.

B. Demonstrate proper pipe preparation by beveling, cleaning, aligning, spacing and tack welding, prior to welding.

C. Gas weld with a 1/8" triple doxidized rod a V-butt joint in the horizontal fixed position a 2" mild steel pipe. In doing this he will apply all pertinent safety precautions as stipulated in IS.1.1.1.1 and identify and apply the correct procedures and methods of correcting faults. Evaluation will be based on the Qualification Test for AR-3 level of American Welding Society standard for Qualification Test for AR-3 level of American Welding Society standard for Qualification of Welding Procedures and Welders for Piping and Tubing, AWS D-10.9-72 condensed in standard STT-FT-1 attached to the unit. The final weld must meet the minimum requirements established for gas welding pipe in the horizontal fixed non restricted position.

UNIT 2

Upon completion of this unit the student will have: Bronzed welded a singel vee butt joint of mild steel 3/16" x 4" x 6" with an Oxy-gas torch in the flat position. Bronze welded to a tee joint of mild steel 3/16" x 4" x 6" with an Oxy-gas torch in the flat position. Bronze welded a lap joint of mild steel 3/16" x 4" x 6" with an Oxy-gas torch in the flat position The above shall be done in accordance with STT -FT-1

Selected proper soldering copper, flux and solder for the metal to be soldered. Solder sheet metal by preparing the metal and soldering coppers prior to soldering common metals used in the sheet metal shop. All safety precautions and practices must be observed. Completed projects must not exceed a tolerance of 1/8" plus or minus on any given measurement.

2.2.1 General Brazing
Upon completion of this topic the student will have:

A. Bronze welded a single vee butt joint of mild steel 3/16" x 4" x 6" with an Oxy-gas torch in the flat position.

B. Bronze welded a tee joint of mild steel 3/16" x 4" x 6" with an Oxy-gas torch in a flat position.

C. Bronzed welded a lap joint of mild steel 3/16" x 4" x 6" with an Oxy-gas torch in the flat position.

D. The above shall be done in accordance with STT-FT-1.

2.2.2 Topic: Soldering
Upon completion of this topic the student will have:

A. Selected proper soldering copper, flux, and solder for the metal to be soldered.

B. Solder sheet metal by preparing the metal and soldering coppers prior to soldering common metals used in the sheet metal shop.

C. All safety precautions and practices must be observed. Completed projects must not exceed a tolerance of 1/8" inch plus or minus on any given measurement.

PHASE 3

UNIT 1

Upon completion of this unit the student will have: Silver brazed a square butt joint of 1/8" x 1" x 2" mild steel with an Oxy-gas torch in the flat position. Silver brazed a tee joint of 1/8" x 1" x 2" mild steel with an Oxy-gas torch in the flat position. Silver brazed a lap joint of 1/8" x 1" x 2" mil steel with an Oxy-gas torch in the flat position. Silver brazed a square butt joint of 1/16" x 1" x 2" brass with an Oxy-gas torch in the flat and vertical position. Silver brazed a tee joint of 1/16" x 1" x 2" brass with an Oxy-gas torch in the flat position and vertical position. Silver brazed a 1/4" lap joint of 1/16" x 1" x 2" brass with an Oxy-gas torch in the flat and vertical position. Silver brazed a tee joint of stainless steel 1/16" x 1" x 2" with an Oxy-gas torch in the flat and vertical posiiton. Silver brazed a ¼" lap joint of stainless steel 1/16" x 1" x 2" with an Oxy-gass torch in the flat and vertical position. The above shall be done with a joint tolerance of .0015 to .003 and with no build up.

3.1.1 Topic: Silver Brazing Steel
Upon completion of this topic the student will be able to:

A. Silver braze a square butt joint of 1/8" x 1" x 2" mild steel with an oxy-gas torch in the flat position.

B. Silver braze a tee joint of 1/8" x 1" x 2" mild steel with an oxy-gas torch in the flat position.

C. Silver braze a lap joint of 1/8" x 1" x 2" mild steel with an oxy-gas torch in the flat position.

D. The above shall be done with a joint tolerance of .0015 to .003 with no build up.

3.1.2 Topic: Silver Brazing Brass
Upon completion of this topic the student will be able to:

A. Silver braze a square butt joint of 1/16" x 1" x 2" brass with an oxy-gas torch in the flat and vertical position.

B. Silver braze a tee joint of 1/16" x 1" x 2" brass with an oxy-gas torch in the flat and vertical position.

C. Silver braze a ¼" lap joint of 1/16" x 1" x 2" brass with an oxy-gas torch in the flat and vertical position.

D. The above shall be done with a joint tolerance of .0015 to .003 and with no build ups.

3.1.3 Topic: Silver Brazing Stainless
Upon completion of this topic the student will be able to:

A. Silver braze a tee joint of stainless steel 1/16" x 1" x 2" with an oxy-gas torch in the flat and vertical position.

B. Silver braze a ¼" lap joint of stainless steel 1/16" x 1" x 2" with an oxy-gas torch in the flat and vertical position.

C. The above shall be done with a joint tolerance of .0015 to .003 and with not build up.

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ANNEX 1

BIBLIOGRAPHY

TEXTS

Steelworker 3 & 2 NAVPERS - 10653E
Operator's Manual Welding Theory and Application TM-9-237
Welding Encyclopedia, 16th Edition, Monticello Books, Morton Grove, Illinois, 60053
The Welding Materials Manual NAVFAC P-433.

REFERENCES:

Naval Construction force Safety Manual COMCBPAC/COMCB/LANT INST 5100.1
American Welding Society, Standard for Qualification of Welding Procedures and Welders for Piping and Tubing AWS-D-10.9-72
"Brazing Manual" American Welding Society Construction Print Reading in the field, TM-704, chapter 2.
Blueprint Reading and sketching NAVPERS 10077C
Blueprint Reading, NAVSCON 064-231

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ANNEX II

EQUIPMENT REQUIREMENTS LIST

Oxy-Mapp Cutting and Welding Unit, FSN:NA, 10 units required, cost: $438.00

Appropriate testing equipment to check quality of welds.

Pedestal Grinder FSN: 3415-204-0035, 2 units required, cost: $478.00

Pipe Beveling Machine FSN:NA, 1 unit required cost: $500.00

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ANNEX III

INSTRUCTIONAL MATERIALS

Film:

MN-37- Behind the Shop Drawing (16 min)
MN-7831-I The Use of Soldering Coppers (8 min)
MC-6797A Engineering Drawing - Orthogragphic Projection (18 min)
MN-9753 "On Solder" (25 min) obsolete

Information Sheet:

Safety Prcautions
Gas Welding and Brazing Testing Standards

Models:

Samples of pipes beveled, spaced and tacked
Samples of pipes showing bead placement
X-Rays showing defects in welds and good welds
Samples of soldered, brazed and silver brazed joints.

Instructor Aids:

16 mm Projector

Tools:

1. Soldering Coppers
2. Chipping hammer
3. Pliers, 8"
4. Gloves
5. Spark lighter
6. Tip cleaners
7. Gloves
8. Goggles
9. Wire brush

Materials:

1. Pencils
2. Paper
3. Sheet metal (18 ga)
4. Solder (50/50)
5. Rags
6. Fluxes:
    a. Brazing
    b. Silver brazing
    c. Soldering
7. Pipe, Mild steel (2")
8. Oxygen
9. Mapp gas
10. Triple deoridized Gas Welding rod 1/8"

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Materials, cont.

11. Bronze rod (flux coated 1/8")
12. Silver brazing alloy 1/16"
13. Chalk
14. Steel Plate 3/16"
15. Brass 1/16"
16. Stainless 1/16"
17. Steel Plate 1/8"
18. Samples of electrodes and rods that are in the T.O.A.

ANNEX IV

MASTER SCHEDULE
GAS CUTTING/WELDING II
STEELWORKER SCHOOL

FIRST WEEK

Topic No.	Type	Period	Topic	Ratio
FIRST DAY				
1.1.1	C	1	Blueprint Reading	5/1
1.1.1	C	2	Blueprint Reading	5/1
1.1.1	S	3	Blueprint Reading	5/1
1.1.1	S	4	Blueprint Reading	5/1
1.1.1	S	5	Blueprint Reading	5/1
1.1.1	S	6	Blueprint Reading	5/1
1.1.1	S	7	Blueprint Reading	5/1
SECOND DAY				
1.1.1	S	8	Blueprint Reading	5/1
1.1.1	S	9	Blueprint Reading	5/1
1.1.2	C	10	Welding Electrodes, Rods and Welding Aids	5/1
1.1.2	C	11	Welding Electrodes, Rods and Welding Aids	5/1
1.1.2	C	12	Welding Electrodes, Rods and Welding Aids	5/1
1.1.2	C	13	Welding Electrodes, Rods and Welding Aids	5/1
1.1.2	C	14	Welding Electrodes, Rods and Welding Aids.	5/1
THIRD DAY				
1.2.1	C	15	Annealing, Hardening & Tampering	5/1
1.2.1	C	16	Annealing, Hardening & Tampering	5/1
1.2.1	C	17	Annealing, Hardening & Tampering	5/1
1.2.1	S	18	Annealing, Hardening & Tampering	5/1
1.2.1	S	19	Annealing, Hardening & Tampering	5/1
2.1.1	C	20	Gas Welding Pipe, Vertical Position	5/1
2.1.1	S	21	Gas Welding Pipe, Vertical Position	5/1
FOURTH DAY				
2.1.1	S	22	Gas Welding Pipe, Vertical Position	5/1
2.1.1	S	23	Gas Welding Pipe, Vertical Position	5/1
2.1.1	S	24	Gas Welding Pipe, Vertical Position	5/1
2.1.1	S	25	Gas Welding Pipe, Vertical Position	5/1
2.1.2	S	26	Evaluation of Gas Welding Pipe, Vertical Position	5/1
2.1.2	S	27	Evaluation of Gas Welding Pipe, Vertical Position	5/1
2.1.3	S	28	Gas Welding Pipe, Horizontal Position	5/1

SECOND WEEK

Topic No	Type	Period	Topic	Ratio
FIRST DAY				
2.1.3	S	1	Gas Welding Pipe, Horizontal Position	5/1
2.1.3	S	2	Gas Welding Pipe, Horizontal Position	5/1
2.1.3	S	3	Gas Welding Pipe, Horizontal Position	5/1
2.1.3	S	4	Gas Welding Pipe, Horizontal Position	5/1
2.1.4	S	5	Evaluation of Gas Welding Pipe, Horizontal Position	5/1
2.1.4	S	6	Evaluation of Gas Welding Pipe, Horizontal Position	5/1
2.2.1	S	7	General Brazing	5/1
SECOND DAY				
2.2.1	S	8	General Brazing	5/1
2.2.1	S	9	General Brazing	5/1
2.2.1	S	10	General Brazing	5/1
2.2.1	S	11	General Brazing	5/1
2.2.1	S	12	General Brazing	5/1
2.2.2	C	13	Soldering	5/1
2.2.2	S	14	Soldering	5/1
THIRD DAY				
2.2.2	S	15	Soldering	5/1
2.2.2	S	16	Soldering	5/1
2.2.2	S	17	Soldering	5/1
3.1.1	C	18	Silver Brazing steel	5/1
3.1.1	S	19	Silver Brazing steel	5/1
3.1.1	S	20	Silver Brazing steel	5/1
3.1.1	S	21	Silver Brazing steel	5/1
FOURTH DAY				
3.1.2	S	22	Silver Brazing Brass	5/1
3.1.2	S	23	Silver Brazing Brass	5/1
3.1.2	S	24	Silver Brazing Brass	5/1
3.1.3	S	25	Silver Brazing Stainless	5/1
3.1.3	S	26	Silver Brazing Stainless	5/1
3.1.3	S	27	Silver Brazing Stainless	5/1
3.1.3	S	28	Silver Brazing Stainless	5/1

NAVAL SCHOOLS CONSTRUCTION
PORT HUENEME, CA 93043

STEELWORKER STT SCHOOL TRAINING COURSE [illegible]

INFORMATION SHEET

SAFETY PRECAUTIONS

INTRODUCTION: This information sheet is designed to provide information on safety precautions and proper actions in case of fire.

SUBJECT MATTER:

1. Alcoholic liquors or narcotics shall not be transported to the school or working area, and no man shall go to work while under the influence of liquor or narcotics.

2. Fighting, wrestling, or throwing of objects and horseplay is positively prohibited.

3. Strict attention to duty is the first requirement of safety. You are warned against permitting your attention to be distracted from your work as this is the cause of many injuries. "Keep your mind on your work and safety on your mind".

4. Do not talk to or distract the attention of machine and equipment operators while the machines or vehicles are in operation.

5 .Obey warning signs and tags. Their purpose is to point out hazards. To disregard them is to diliberately invite injury.

6. No one is permitted to ride on fenders, running boards, or bus steps; nor to ride standing on truck bodies.

7. Employees riding on trucks or other vehicles must keep arms and legs inside the body of the vehicle at all times. Sitting on side boards is prohibited.

8. No one is permitted to get on or off a moving vehicle.

9. Never try to operate any equipment unless you are familiar with its operation and have been authorized to do so.

10. Report to your supervisor any defects in equipment or any other condition which might cause an accident.

11. Remember that at all times some of your co-workers on the job are inexperienced and may not know when or where danger exists. Warn any man when danger is near. He may know all about it; if so no harm is done.

12. Be constantly aware and stay clear of moving equipment and material

13. You are in danger when you are in a posiiton between a moving piece of equipment or load of material and a stationary object.

14. Do not use a box, chair, barrell, or other makeshift in place of a ladder.

15. Leaning tools or materials against walls, columns, or machines is an unsafe practice.

16. Cleaning, oiling, repairing, or adjusting machinery or equipment while it is in motion may cause serious injury and is prohibited.

17. Always use all safeguards provided. See that all guards or other protective devices are in place before Beginning work.

18. Any extension lamp, power tool, welding cable, etc. with frayed insulation, loose connection, or damaged plug should be repaired or replaced immediately.

19. Do not touch, handle or tamper with any electrical equipment, air, water, gas, oil, or steam line, or machinery which does not come within your regular duties unless you have received permission and instructions from your supervisor.

20. Do not throw any switch, turn any air, water, steam or oil valve, or start any machine without first making certain that everything is in the clear and that no worker will be injured by such action.

21. In doing work entailing possible eye injury, protect the eyes by wearing the proper type of safety goggles provided for this purpose

22. Every precaution must be taken to prevent fires. Extinguish all lighted matches, cigarettes or cigars before throwing them away.

23. Throw waste paper, oily rags, and other refuse in containers provided for that purpose.

24. Keep aisles, stairways, exits, and fire equipment clear of obstruction at all times.

25. In case of fire turn in the alarm and return to the scene of the fire to help in extinguishing it.

STT-615.2-SW-IS. 1.1.1.1

JUNE 1974

OXY-MAPP WELDING PHASE

YOU WILL:

1. Observe all safety rules.
2. Wear gloves while welding and burning
3. Wear the welding goggles provided.
4. Use pliars to pick up hot metal.
5. Use safety shields while grinding.
6. Properly stow tools and equipment.
7. Replace oxy-mapp bottles when found empty.
8. Clean your booth and area.
9. Use only materials designated by the instructor.
10. Take breaks on east side of building.

YOU WILL NOT:

1. Wear gloves whild grinding.
2. Use goggles while grinding.
3. Put fire bricks or plates in drawers.
4. Misuse welding equipment.
5. Weld on face of plates
6. Waste plates or welding rod.
7. Weld anything other than that specified by the instructor.
8. Bend plates unless instructed to do so by the instructor.
9. Leave a mess for someone else to clean.
10. Throw trash in metal dumpsters.
11. Play or fool in shops or with another mans tools and equipment
12. Bring any type of food or beverage into the shops.
13. Go th the exchange on gedunk break.
14. Leave the area without instructors approval.

STEELWORKER SCHOOL

STT

GAS WELDING AND BRAZING PRACTICAL

TESTING STANDARDS

OBJECTIVES: 1. Using a 1/8" triple de-oxidized mild steel welding rod, the student will oxy-MAPP weld, in the flat position, a butt joint, a lap joint, and a corner joint. Base metal will be 10 g. a. mild steel. Welds are to be made using the forehand method.

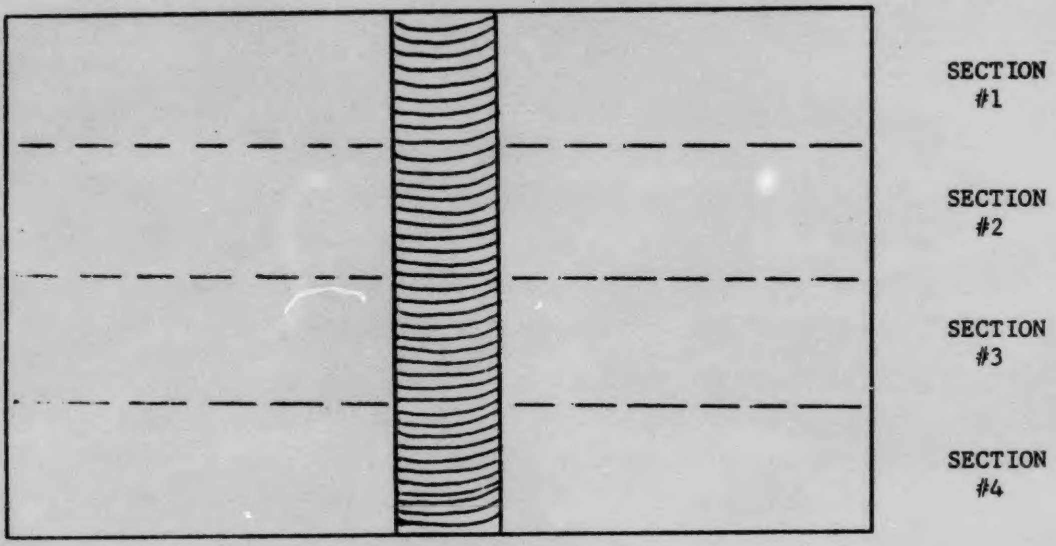
2. Using a 1/8" brass brazing rod and sufficient flux, the student will oxy-MAPP torch braze in the flat position, a butt joint, a lap joint, and a corner joint. Base metal will be 10 g.a. mild steel. All brazing is to be done by the forehand method.

To ensure impartial grading an instructor other than the person actually instructing the class will perform the grading.

INSTRUCTOR'S GUIDE FOR GRADING

OXY-MAPP GAS WELDING AND BRAZING PRACTICAL TEST

1. With soapstone, divide the test plate into four 1" sections as illustrated:



GRADING

2. Weld or Braze
   A. Appearance
      (1) The ripples formed by the deposited filler metal must present a uniform appearance. For each section that does not have a uniform ripple appearance, up to two points may be subtracted. Maximum loss is two points per section maximum loss per plate is eight points.
      (2) The build up of filler metal must not exceed 1/8" in height from the face of the plate. For each section that the filler buildup exceeds 1/8" up to two points may be subtracted. Maximum loss is two points per section. Maximum loss per plate is eight points.
      (3) The width of the welded/brazed area must not exceed 5/8". For each section that the welded/brazed area exceeds 5/8", up to two points may be subtracted. Maximum loss is two points per section. Maximum loss per plate is eight points.

B. UNDERCUT

(1) For each section that an undercut is melted into the base metal and left unfilled by the filler metal, up to two points may be subtracted. Maximum loss is two points per section. Maximum loss per plate is eight points.

C. OVERLAP

(1) For each section that the protrusion of the filler metal is beyond the bond of the filler metal, up to two points may be subtracted. Maximum loss is two points per section. Maximum loss per plate is eight points.

D. PENETRATION

(1) The root filler metal must extend below the surface of the plates being welded/brazed. For each section that the root filler metal does not extend below the surface, up to two points may be subtracted. Maximum loss is two points per section. Maximum loss per plate is eight points.

(2) For each section that the root filler metal extends below the surface in excess of 1/8", up to two points may be subtracted. Maximum loss is two points per section. Maximum loss per plate is eight points.

3. Guided Bend Test

A. Butt Joint-Face Bend

(1) With the face of the first section to be bent facing down on the bending guide, pressure will be applied so as to bend the section in a "v" shape as stated in the code for Welding in Building Construction, AWS DI.0-69.

Points may be deducted as follows:

If the filler metal separates from base metal 1/8" to 1/2"= 2 points
" " " " " " " " 1/2" to 1" = 4 points
" " " " " " " " 1" to 11/2" = 6 points
" " " " " " " " 1½" to 2" = 8 points

B. Butt Joint-Root Bend

(1) With the root of the second section to be bent facing down on the bending guide, pressure will be applied so as to bend the section in "U" shape as stated in the code for Welding in Building Construction, AWS DI.0-69.

Points may be deducted as follows:

If the filler metal separates from base metal 1/8" to 1/2" = 2 points
" " " " " " " " 1/2" to 1" = 4 points
" " " " " " " " 1" to 1 1/2" = 6 points
" " " " " " " " 1 1/2" to 2" = 8 points

C. Lap Joint-Face Bend

(1) The grading instructor will decide which side of Lap joint is to be used for the face bend test.

(a) With the selected side to be bent facing down on the bending guide, with lap joint between bending guide shoulders, pressure will be applied so as to bend the section in a "U" shape as stated in the Code for Welding in Building Construction, AWS DI. 0-69.

Points may be deducted as follows:

If the filler metal separates from base metal 1/8" to 1/2" = 4 points
" " " " " " " " 1/2" to 1" = 8 points
" " " " " " " " 1" to 1 1/2" = 12 points
" " " " " " " " 1 1/2" to 2" = 16 points

D. Corner Joint

(1) With the legs of the test specimen facing down on a hard flat surface a force shall be applied until rupture occurs or specimen flattens upon itself. The force may be applied by any convenient means.

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NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043

STEELWORKER STT SCHOOL TRAINING COURSE 615-2

Classification: Unclassified

Topic: Blueprint Reading

Average Time: Class : 2 periods
Pract : 7 periods

Instructional Materials:

A. References

1. TM5-704- Construction Print Reading in the Field Chapter 2

2. NAVPERS 10077-C - Blueprint Reading and Sketching, Chapter 1, pages 1-13

B. Programmed Instruction

1. Blueprint Reading, NAVSCON 064-231

C. Film

1. MN-37 - Behind the Shop Drawing (16 min)

2. MC-6797A - Engineering Drawing, Othographic Projection (18 min)

D. Transparencies

1. None

E. Instructional Aids:

1. 16 MM movie projector

Terminal Objective: 1.1

Enabling Objectives: Upon completion of this topic the student will be able to:

A. Read simple prints for shop work: Identify title box and read notes and specifications as found on simple prints: all must be with 100% accuracy.

Criterion Tests: The student will read simple prints for shop work. Identify title box and read notes and specifications as found on simple prints. All must be done with 100% accuracy.

Homework: Reading Assignment: NAVPERS 10653-E Steelworker 3 & 2, Chapter 5, pages 51-59

F. Tools:

1. None

G. Equipment

1. None

H. Materials:

1. Pencils

2. Paper

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the Lesson	1. Introduce self and topic.	
A. Establish contact.		
1. Name:		
2. Topic: Basic Blueprint Reading		
B. Establish readiness	2. Motivate student.	
1. Purpose		
2. Assignment		
C. Establish effect	3. Bring out need and value of material being presented.	
1. Value		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better steelworker		
D. Overview:	4. State learning objectives.	
1. State objectives		
2. Notes	a. State information and materials necessary to guide student.	
3. Questions		
4. Testable		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation	5. Show film MN-37, Behind the shop Drawing.	1. Watch film.
A. Purpose and makeup of prints.		
1. Convey ideas and details		
2. Copy of a drawing.		
a. Blueprint (white on blue)		
b. Black and white (black on white)		
c. Ozalids (black, maroon, purple, or blue on white)		
d. Van Dykes (white on dark brown).		
e. Negative phosphates (white on gray).		
3. Lines		
4. Dimensions		2. Take notes
5. Notes		
B. Basic lines		
1. Object		
a. Visible outline of object.		
b. Thick and solid.		
2. Hidden		
a. Hidden outline of object		
b. Medium and broken		

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OUTLINE OF INSTRUCTION

3. Center
    - a. Center of circles, arc, radii, and symmetrical objects.
    - b. Fine and broken (alternating long and short)
    - c. Aid in dimensioning.
4. Extension
    - a. Extension of outline
    - b. Fine and solid
    - c. Used with dimension lines
    - d. Starts 1/16" from object line.
5. Dimension line
    - a. Locates dimensions.
    - b. Fine and solid lines.
    - c. Touches extension lines with arrowheads.
    - d. Broken only for dimensions.
        - (1) Usually at center
        - (2) Stagger dimensions (one above other)
6. Leader
    - a. Points to location
    - b. Fine and solid with arrowhead at one end.

INSTRUCTOR ACTIVITY

6. Use chalkboard as necessary to intensify learning.

STUDENT ACTIVITY

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Used to locate notes, specs, of sizes		
7. Cutting plane		
a. Indicates imaginary cut		
b. Heavy and broken.		
c. Alternating long and two short dashes.		
d. Arrowheads at 90° on each end.		
e. Shows cross-sectional areas.		
8. Short break		
a. Indicates section removed.		
b. Heavy and irregular (freehand).		
c. Small % of object removed.		
9. Long break	7. Questions to class at random.	3. Answer questions as asked by instructor.
a. Indicates section removed.		
b. Light ruled with freehand zig zags.		
c. Great % of object removed.		
10. Phantom or alternate position		
a. Used to show secondary position		
b. Medium alternating long with two short dashes. Exercise on identification of lines.		

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

C. Views (Orthographic Projection

1. Front
    a. Most details
    b. Length and height.
    c. Lower left corner of print.
2. Top
    a. Length and width
    b. Above and in line with front view
3. Right side
    a. Width and height
    b. To the right and in line with front view.
4. Back and left
    a. Generallly not needed.
    b. Occupy relative positions if used.
5. Auxiliary
    a. Cutting plane
        (1) Shows inside
        (2) Shows cross section.

OUTLINE OF INSTRUCTION

- b. Inlined plane
  - (1) Shows sloped surfaces
  - (2) Projected parallel to sloped surface.

D. Notes

- 1. Notes
  - a. Apply generally to object
  - b. Tells what but not how.
  - c. May include sizes.
- 2. Specifications
  - a. Gives specifics
  - b. Process (how or when to do).
  - c. Material
  - d. Number or amount
- 3. Location
  - a. Near view concerned (leader)
  - b. In open area
  - c. Title block

E. Title block

- 1. Lower right-hand corner
- 2. Name or part.

INSTRUCTOR ACTIVITY

8. Show film MC - 6797A "Engineering Drawing" Orthographic Projection

STUDENT ACTIVITY

4. Watch film

5. Take notes

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
3. Number of drawing		
4. Material		
5. Number required.		
6. Order number		
7. Date		
8. Originator		
9. Revisions		
10. Scale		
F. Bills of materials		
1. Type of stock		
2. Shape of stock		
3. Size		
4. Amount (total for order).		
G. Dimensioning		
1. Purpose		
a. Size		
b. Location		
2. Types		
a. Fractional		
b. Decimal		
c. Degrees		

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
H. Scale (to reduce of expand for clarity)		
1. Types		
a. Full (1 = 1)		
b. 1/2 = 1 (1 = 2)		
c. 1/4 = 1 (1 = 4)		
d. 4 = 1		
e. 2 = 1		
2. Calculating from scale		
a. Full - no calculating		
b. 1/2 = 1 size times 2.		6. Take notes
c. 1/4 = 1 size times 4		
d. 4 = 1 size divided by 4		
e. 2 = 1 size divided by 2		
3. Examples (drawings to object)	9. Questiong to class at random	7. Answer questions as asked by instructor.
a. 8" @ 1/4 = 1 scale = 32"		
b. 13" @ 1/2 = 1 scale = 25"		
c. 12" @ 4 = 1 scale = 3"		
d. 13" @ 2 = 1 scale = 6-1/2"		

OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

4. Examples (object to drawing).
   - a. 8" @ ¼ = 1 scale - 2"
   - b. 13" @ ½ = 1 scale = 6-½"
   - c. 12" @ 4 = 1 scale = 48"
   - d. 13" @ 2 = 1 scale = 26"

I. Tolerances
   1. Allowance
      - a. Amount oversize
      - b. Amount undersize
      - c. May be fraction, decimal or degree
   2. Plus, minus, or both

J. Sets of drawings.
   1. Master print
      - a. Shows entire job
      - b. May be several sheets
      - c. Will have several views of elevation
      - d. Will have general information.
   2. Assembly prints
      - a. Sometimes called erection print
      - b. Shows how to assemble
      - c. Same number as master print.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
3. Subassembly prints		
a. Shows how one part joins another		
b. Same number as master print		
4. Detailed prints		
a. Shows enlarged section of an individual part.		
b. Shows how made		
c. Same number as master print		
d. Sectional drawings (small parts).	10. Hand out Welding symbol instruction sheet.	
K. Welding symbols	11. Hand out Programmed Instruction Blueprint Reading, NAVSCON 064-231	
II. Application		
A. Students will complete Programmed Instruction "Blueprint Reading" NAVSCON 064-231, with 100% accuracy.	12. Instruct students to complete programmed instruction, assist students when necessary	8. Complete programmed instruction, ask instructor for assistance when necessary.
	13. Collect completed programmed instructions.	
B. Questions to class at random		9. Answer questions as asked by instructor.
II. Summary:		
A. Purpose and makeup		
1. Convey ideas		
2. Copy of drawing		

OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

3. Lines
4. Dimensions
5. Notes

B. Basic lines

1. Object
2. Hidden
3. Center
4. Extension
5. Dimension
6. Leader
7. Cutting plane
8. Short break
9. Long break
10. Phantom or alternate position.

C. Views

1. Front
2. Top
3. Right side
4. Back and left
5. Auxiliary

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
D. Notes and specifications		
1. Notes		
2. Specifications		
3. Location		
E. Title block		
1. Location		
2. Part		
3. Number of drawing		
4. Material		
5. Quantity		
6. Order number		
7. Date		
8. Originator		
9. Revisions		
10. Scale		
F. Bill of material		
1. Type		
2. Shape		
3. Size		
4. Amount (total)		

OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

G. Dimensioning

  1. Purpose

  2. Types

H. Scale

  1. Types

  2. Calculationg

  3. Examples (drawing to object).

  4. Examples (object to drawing).

I. Tolerances

  1. Allowance

  2. Plus, minus, or both

J. Sets of drawings.

  1. Master

  2. Assembly

  3. Sub-assembly

  4. Detail

VIII. TEST

A. Written test

  1. 8 of 10 questions to be answered correctly

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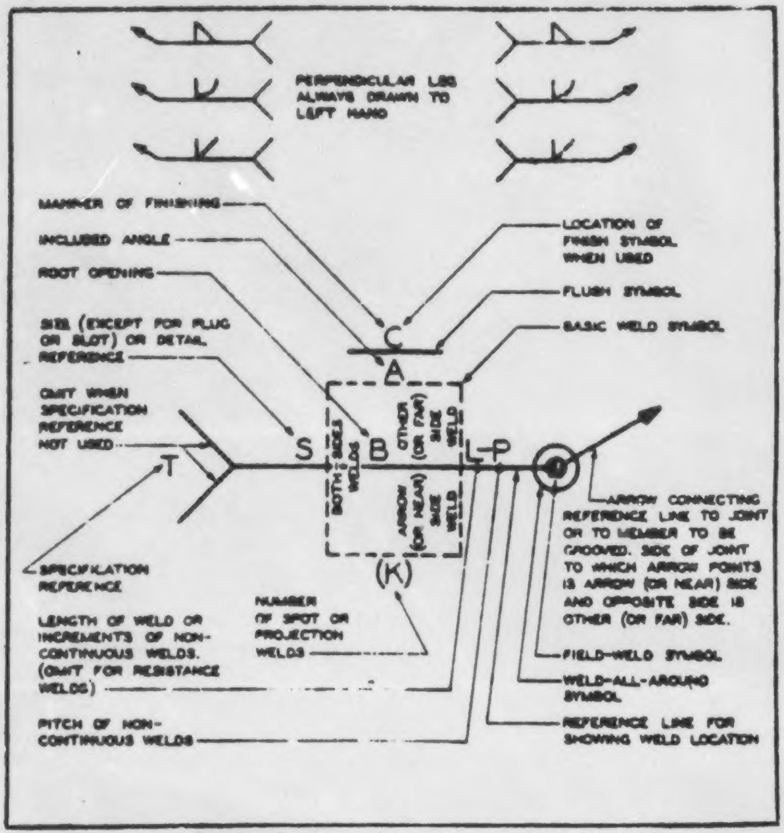
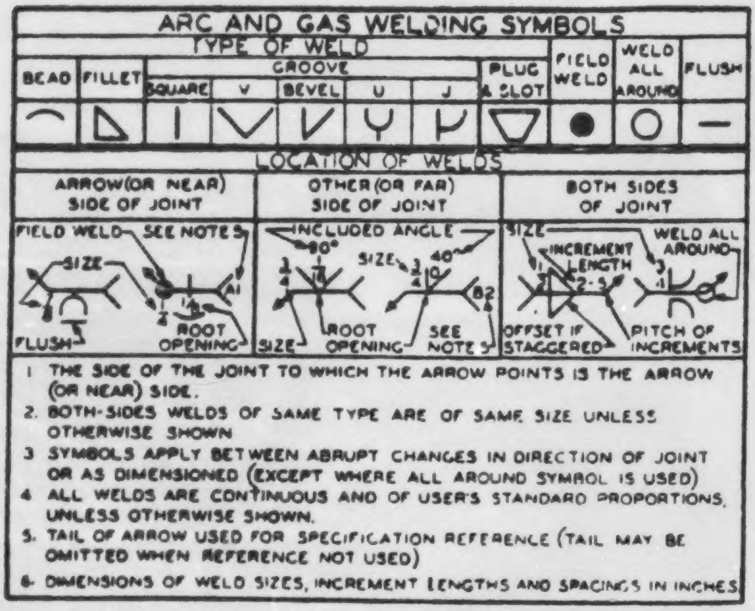

PERPENDICULAR LEG ALWAYS DRAWN TO LEFT HAND
MANNER OF FINISHING
INCLUDED ANGLE
ROOT OPENING
SIZE (EXCEPT FOR PLUG OR SLOT) OR DETAIL REFERENCE
OMIT WHEN SPECIFICATION REFERENCE NOT USED
SPECIFICATION REFERENCE
LENGTH OF WELD OR INCREMENTS OF NON-CONTINUOUS WELDS. (OMIT FOR RESISTANCE WELDS)
PITCH OF NON-CONTINUOUS WELDS
NUMBER OF SPOT OR PROJECTION WELDS
LOCATION OF FINISH SYMBOL WHEN USED
FLUSH SYMBOL
BASIC WELD SYMBOL
C
A
T
S
B
L-P
(K)
BOTH SIDES WELDS
OTHER (OR FAR) SIDE WELD
ARROW (OR NEAR) SIDE WELD
ARROW CONNECTING REFERENCE LINE TO JOINT OR TO MEMBER TO BE GROOVED. SIDE OF JOINT TO WHICH ARROW POINTS IS ARROW (OR NEAR) SIDE AND OPPOSITE SIDE IS OTHER (OR FAR) SIDE.
FIELD-WELD SYMBOL
WELD-ALL-AROUND SYMBOL
REFERENCE LINE FOR SHOWING WELD LOCATION

Standard Location of Information on Welding Symbols


ARC AND GAS WELDING SYMBOLS
TYPE OF WELD
BEAD
FILLET
GROOVE
SQUARE
V
BEVEL
U
J
PLUG & SLOT
FIELD WELD
WELD ALL AROUND
FLUSH
LOCATION OF WELDS
ARROW (OR NEAR) SIDE OF JOINT
OTHER (OR FAR) SIDE OF JOINT
BOTH SIDES OF JOINT
FIELD WELD
SEE NOTE 5
SIZE
FLUSH
ROOT OPENING
A1
INCLUDED ANGLE
90°
40°
SIZE
ROOT OPENING
SEE NOTE 5
B2
INCREMENT LENGTH
2-5
WELD ALL AROUND
OFFSET IF STAGGERED
PITCH OF INCREMENTS

1 THE SIDE OF THE JOINT TO WHICH THE ARROW POINTS IS THE ARROW (OR NEAR) SIDE.

2. BOTH-SIDES WELDS OF SAME TYPE ARE OF SAME SIZE UNLESS OTHERWISE SHOWN

3 SYMBOLS APPLY BETWEEN ABRUPT CHANGES IN DIRECTION OF JOINT OR AS DIMENSIONED (EXCEPT WHERE ALL AROUND SYMBOL IS USED)

4 ALL WELDS ARE CONTINUOUS AND OF USER'S STANDARD PROPORTIONS, UNLESS OTHERWISE SHOWN.

5. TAIL OF ARROW USED FOR SPECIFICATION REFERENCE (TAIL MAY BE OMITTED WHEN REFERENCE NOT USED)

6 DIMENSIONS OF WELD SIZES, INCREMENT LENGTHS AND SPACINGS IN INCHES.

Legend for Use on Drawings Specifying Arc and Gas Welding

NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043
STEELWORKER STT SCHOOL TRIAINIGN COURSE 615-2

Classification: Unclassified

Topic: Welding Electrodes, Rods and Welding Aids.

Average Time: Class: 5 periods

Instructional Materials:

A. Training Aids

B. Publications

1. Texts

   a. Operator's Manual Welding Theory and Application TM9-237, pages 69-74

   b. The Welding Materials Manual Navfac P-433

   c. Welding Encyclopedia 16th edition

2. References : None

C. Equipment and Materials

1. Major Equipment: None

2. Tools: None

Terminal Objective: 1.1

Enabling Objectives:
Upon completion of this topic the student will have:

1. Identified the welding consumables in the Mobile Construction Battalion Table of Allowance, Namely arc welding electrodes. Gas welding rods, wearfacing electrodes and welding aids. Stated their primary use and secondary use when applicable without error.

Criterion Test:

The student will identify the welding consumables in the Mobile Construction Battalion Table of Allowance, Namely arc welding electrodes, gas welding rods, wearfacing electrodes, and welding aids. State their primary use and secondary use when applicable without error.

Homework:

Reading Assignment:

1. Operators Manual Welding Theory and application, TM9-237 Chapter 2, pages 5-12

3. Materials:

   a. Gas welding rods

   b. Arc welding rods

   c. Wearfacing rods

   d. Holding and heat-resisting compound

   e. Surface hardening-case compound

   f. Molicular Metal

D. InstructorPrepared Materials: (Local)
None

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the Lesson A. Establish contact. 1. Names 2. Topic: Welding Electrodes, Rods and Welding Aids.	1. Introduce self and topic.	
B. Establish readiness 1. Purpose 2. Assignment	2. Motivate student.	
C. Establish effect 1. Value a. Pass course. b. Perform better on the job. c. Get advanced. d. Be a better steelworker	3. Bring out need and value of material being presented.	
D. Overview: 1. Welding Consumables a. Identification b. Primary use c. Secondary use d. Characteristics	4. State learning objectives. a. State information and materials necessary to guide student.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. PRESENTATION		
A. Welding Consumables:		
Note: Use Section 1 of the "Welding Materials Manual" in the instruction of this topic.		1. Take notes
1. Arc welding electrodes		
a. AWS E6011		
(1) Primary use	5. Pass out samples of E6011 Electrode	2. Student exam E6011 electrode
(a) Mild steel		
(b) Galvanized steel	6. Questions to students at randum to check comprehension.	
(2) Secondary use		
(a) Cutting rod		
(b) Buildup prior to wearfacing.		
(3) Characteristics		
(a) Deep penetration		
(b) Light slag		
(c) Fast freezing deposit		
(d) Tensile strength 62000 to 72000 PSI.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
b. AWS E6012	7. Pass out samples of E6012 Electrode	3. Student exam E6012 Electrode
(1) Primary use		
(a) Mild steel		
(b) Rusty steel		
(c) Poor fit-up joints		
(d) Thin sections		
(2) Secondary use		
(a) Build up prior to wearfacing		
(3) Characteristics		
(a) Shallow penetration		
(b) Can use high amperage.		
(c) Low spatter		
(d) Vertical down welding		
(e) Tensile strength 67,000 to 80,000 PSI.		
c. AWS E7018	8. Pass out samples of E7018 Electrode	4. Student exam E7018 electrode
(1) Primary use		
(a) For high quality X-ray welds on mild steel		
(b) Low alloy structural steels		
1. Cor-Ten		
2. Mayari R		
3. Lukens 45 and 50		

OUTLINE OF INSTRUCTION

4. Yoloy

(c) Pipe welding

(2) Secondary use

(a) Build up prior to wearfacing

3. Characteristics

a. Soft quiet arc

b. Low spatter

c. Tensile strength 70.000 to 78,000 PSI.

d. AWS E11018

(1) Primary use

(a) For high quality X-ray welds on low alloy high-strength steels.

1. T-1

2. Hy 80

3. Hy 90

4. Hy 100

5. SSS 100

6. Jolloy 90

7. Jolloy 100

(2) Secondary use

(a) Build up prior to wearfacing

INSTRUCTOR ACTIVITY

9. Pass out samples of AWS E11018 Electrode

STUDENT ACTIVITY

5. Student exam E11018 Electrode

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(3) Characteristics (a) Fast, efficient metal transfer. (b) Excellent tensile and impact properties (c) Tensile strength 110.000 to 114,000 PSI.		
e. AWS/ASTM E70 S-3 (MIG) (1) Primary use (a) MIG welding low to medium carbon steel. (2) Secondary use (a) Build up prior to wearfacing (3) Characteristics (a) Requirements 1. Work must be clean 2. Must have clean, dry shielding gas. 3. Wire must be clean and dry 4. Tensile strength 78,000 PSI	10. Pass out sample of MIG welding wire	6. Student exam welding wire
f. Aluminum electrode (E4043) arc-flux coated (1) Primary use (a) Metal arc welding of weldable extruded, plate, sheet, and sand and die-cast aluminum.	11. Pass out samples of E-4043 Electrode	7. Student exam E-4043 electrode

OUTLINE OF INSTRUCTION

(2) Secondary use

(a) Can be used with torch, TIG or carbon arc to weld weldable grades of aluminum.

(3) Characteristics

(a) Flux is hydroscopic - Keep Dry !!

(b) Tensile strength 25,500 PSI

g. Aluminum MIG wire (E5356)

(1) Primary use

(a) Aluminum landing mats

(2) Secondary use

(a) For welding aluminum grades 5056,5083,5086, 5154,and 5356.

(b) Can be applied with carbon arc, torch or TIG.

(3) Characteristics

(a) Requirements

1. Work must be clean.

2. Must have clean, dry shielding gas.

3. Wire must be clean and dry

4. Tensile strength 40,500 PSI

5. Yield strength 21,000 PSI

INSTRUCTOR ACTIVITY

12. Pass out sample of MIG Aluminum welding wire.

STUDENT ACTIVITY

8. Student exam.. MIG Aluminum welding wire

OUTLINE OF INSTRUCTION

h. High alloy and tool steels (AWS E312-16)

  (1) Primary use

    (a) Medium, high carbon, alloy and tool steels

    (b) Stainless steels

    (c) Manganese steels

  (2) Secondary use

    (a) All steel-base alloys except cast iron.

    (b) Build up prior to wearfacing

  (3) Characteristics

    (a) Bare rod can be applied with gas or tig torch.

    (b) Tensile strength 120,000 PSI.

i. Cast iron-arc (nickel base)

  (1) Primary use

    (a) Thin cast iron sections,

    (b) Where high machineablility is required

  (2) Secondary use

    (a) For welding disimilar metals

    (b) Can be used to weld nickel, monel, stainless and copper alloys.

    (c) Can be used with TIG

INSTRUCTOR ACTIVITY

13. Pass out sample of E-312-16 electrode

14. Pass out sample of nickel base electrode

STUDENT ACTIVITY

9. Student exam at E-312-1

electrode

10. Student exam, nickel base electrode

OUTLINE OF INSTRUCTION

(3) Characteristics

(a) Highly ductile and machinable.

(b) Excellent for out-of-position work.

(c) Weld metal is hot short.

(d) Tensile strength 50,000 PSI

j. Cast iron-arc (nickel-iron base)

(1) Primary use

(a) Repair all cast iron (heavy and restrained)

(b) Use where weld is subject to air, gas or liquid pressure.

(2) Secondary use

(a) Joining cast iron to steel

(b) Build up prior to wearfacing on cast iron

(3) Characteristics

(a) Weld metal is not hot short

(b) Tensile strength 55,000 - 60,000 PSI

k. Arc brazing

(1) Primary use

(a) High strength joints on cast iron, steel and copper alloys.

INSTRUCTOR ACTIVITY

15. Pass out sample of nickel-iron base electrode

16. Pass out sample of Arc Brazing Electrode

STUDENT ACTIVITY

11. Student exam nickel-iron base electrode

12. Student exam Arc Brazing Electrode.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) Secondary use		
(a) Joining stainless, nickel and nickel alloys.		
(b) Overlay for frictional wear.		
(3) Characteristics		
(a) Crack resistant		
(b) Rapid deposition rate		
(c) Hardness: 130 BHN - Work hardens to 230 BHN.		
(d) Tensile strength: 90,000 PSI		
1. Chamfering rod	17. Pass out sample of chamfering electrode	13. Exam Chamfering Electrode.
(1) Primary use		
(a) Chamfering		
(b) Grooving		
(c) Gouging		
(2) Secondary use		
(a) Piercing		
(b) Heating		
(c) Cutting		
(d) Sear oil-soaked cast iron		
(3) Characteristics		
(a) Rod must be kept in contact with work		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
m. Carbon electrodes	18. Pass out sample of carbon electrode	14. Exam. Carbon electrod
(1) Primary use		
(a) Carbon arc for brazing		
(b) Heating		
(c) Cutting		
(2) Secondary use		
(a) Plug for protecting threads		
(b) Case hardening		
(c) Soldering		
(3) Characteristics		
(a) Rod produces a carbon monoxide and carbon dioxide giving the weld metal some protection.		
2. Gas welding rods	19. Pass out sample of gas welding rod	15. Exam. Gas welding rod
a. Bare mild steel rod		
(1) Primary use		
(a) Low and medium carbon steel (torch or TIG)		
(2) Secondary use		
(a) For fast build up feed this rod into electrode arc stream		
(b) Feed into arc stream of wearfacing rod to stand better impact		
(c) Feed onto kerf when cutting cast iron or stainless with torch		

OUTLINE OF INSTRUCTION

(3) Characteristics

(a) Triple deoxidized

(b) May be used with Mapp or Acetylene gas.

(c) Tensile strength 62,000 PSI

b. Cast iron rod (flux-coated)

(1) Primary use

(a) For gray cast iron where deposit must have same properties of base metal. Example: Exhause manifold

(2) Secondary use

(a) If no wearfacing rod is available it will make a hard deposit if applied with arc.

(3) Characteristics

(a) Resistant to bending, corrosion and heat.

(b) Color matching to cast iron,

(c) Machinable (cool slowly).

(d) Bonding temperature 1400° to 1600°F

(e) Hardness: 200 BHN (slow cooled)

(f) Tensile strength: 40,000 PSI

INSTRUCTOR ACTIVITY

20. Pass out sample of (flux coated) cast iron rod.

STUDENT ACTIVITY

16. Exam. Cast iron rod

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. General brazing rods (flux coated) (1) Primary use (a) Steel (b) Cast iron (c) Brass (d) Bronze (e) Dissimilar metal combination (2) Secondary use (a) Some nickel alloys (keep heat low) (b) Frictional wear overlay (3) Characteristics (a) Low fuming (b) Does not require fusion (c) Tensile strength: 60,000PSI	21. Pass out sample of (flux coated) general brazing rod.	17. Exam. General brazing rod
d. High strength brazing rods (flux coated) (1) Primary use (a) Carbon steels (b) Alloy steels (c) Tool steels	22. Pass out sample of high strength brazing rod.	18. Exam. High strength brazing rod.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) Secondary use		
(a) Brass		
(b) Bronze		
(c) Cast iron		
(d) Frictional wear overlay		
(3) Characteristics		
(a) Bonding temperature 1400 - 1600°F.		
(b) Bead forming or thin flowing		
(c) Tensile strength: 100,000 PSI		
e. Silver brazing kits (with flux)	23. Show contents of silver brazing kits.	19. Observe contents of silver brazing kits.
(1) Primary use		
(a) All ferrous and non-ferrous metals except the white metals. Example:		
1 Instrumentation		
2 Tubing		
3 Controls		
4 Switches		
5 Food vessels		
6 Laboratory apparatus		
7 Hospital equipment		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) Secondary use		
(a) Large work where alignment is important, espiecially on brasses, and close-fitting joints can be maintained.		
(3) Characteristics		
(a) Thin flowing		
(b) Temperature: 1145° - 1205° F		
(c) Tensile strength: 85,000 PSI		
f. Solder (tin-antimony 95/5)	24. Pass out sample of 95/5 solder.	20. Exam. Sample of 95/5 solder.
(1) Primary use		
(a) For joints requiring elevated temperature		
(b) Reftigeration joints		
(2) Secondary use		
(a) Food containers (best solder is 96% tin - 4% silver)		
(3) Characteristics		
(a) Do not use on aluminum, zinc or zinc-coated metals (galvanized iron).		
(b) Melting temperature (solidus 452° F) Flow temperature (liquidus 464° F)		

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
g. Solder (tin-lead 50/50)	25. Pass out sample of 50/50 solder.	21. Exam. Sample of 50/50 solder.
(1) Primary use		
(a) Radiator cores		
(b) Heating units		
(c) Roofing seams		
(2) Secondary uses		
(a) Electrical connections		
(b) Wiping and seating solder		
(3) Characteristics		
(a) Relatively narrow pasty range		
(b) Good wetting properties		
(c) Melting temperature (solidus 361° F)		
(d) Flow temperature (liquidus 421° F)		
h. Solder (tin-lead 40/60 - acid core)	26. Pass out sample of 40/60 solder	22. Exam. Sample of 40/60 solder.
(1) Primary use		
(a) Sheetmetal work		
(b) General small metal work (no extra flux needed)		
(2) Secondary uses		
(a) Can be used on similar work as 50/50 but is more econiomical.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(3) Characteristics		
(a) Melting temperature (solidus 361° F) Flow temperature (liquidus 455° F)		
i. Solder (tin lead 60/40 rosin core)	27. Pass out sample of 60/40 solder	23. Exam. Sample of 60/40 solder
(1) Primary use		
(a) Electrical work		
(2) Secondary use		
(a) Sheetmetal (Use an acid flux		
(3) Characteristics		
(a) Low temperature Melting temperature (Solidus 361° F) Flow temperature (Liquidus 374° F)		
(b) Narrow pasty range		
(c) Flux has low-corrosive nature		
j. Solder (tin-silver 96/4)	28. Pass out sample of 96/4 solder	24. Exam. Sample of 96/4 solder.
(1) Primary use		
(a) Electrical work (has highest electrical conductivity of all the solders.)		
(b) Food and beverage equipment		
(c) Hospital equipment		
(d) Joining disimiliar metals		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) Secondary use		
(a) Refrigeration		
(b) May be used in place of all the other solders but is the most expensive.		
(3) Characteristics		
(a) Cadmium and lead-free		
(b) Retains bright finish		
(c) Good color match on stainless		
(d) High strength		
(e) Good corrosion resistance		
(f) Temperature (solidus and liquidus 430° F)		
(g) Tensile strength 15,000 PSI		
(h) Shear strength 11,200 PSI		
3. Wearfacing electrodes	29. Pass out sample of manganese electrode	25. Exam. Sample of manganese electrode
a. Manganese electrodes		
(1) Primary use		
(a) Severe impact and compression		
(b) Building up and joining manganese.		
(c) Joining steel to namganese.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) Secondary use		
(a) Joining steel to steel		
(b) Joining cast iron		
(c) When out of intermediate wearfacing rod, use this rod.		
(3) Characteristics		
(a) Hardness: As deposited RB 80-90 Work hardened RC 45-50		
(b) Tensile strength: 115,000 PSI		
b. Build up electrode	30. Pass out sample of build up electrode	26. Exam. Sample of build up electrode
(1) Primary use		
(a) Build up of worn steel parts		
(2) Secondary use		
(a) Joining of steel		
(3) Characteristics		
(a) Resistant to heavy shock loading and pounding.		
(b) Resistant to deformation.		
(c) Machinable		
(d) Hardness: RC 30		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) Secondary use		
(a) Joining steel to steel		
(b) Joining cast iron		
(c) When out of intermediate wearfacing rod, use this rod.		
(3) Characteristics		
(a) Hardness: As deposited RB 80-90 Work hardened RC 45-50		
(b) Tensile strength: 115,000 PSI		
b. Build up electrode	30. Pass out sample of build up electrode	26. Exam. Sample of build up electrode
(1) Primary use		
(a) Build up of worn steel parts		
(2) Secondary use		
(a) Joining of steel		
(3) Characteristics		
(a) Resistant to heavy shock loading and pounding.		
(b) Resistant to deformation.		
(c) Machinable		
(d) Hardness: RC 30		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) Characteristics		
(a) Will not increase dimension of part.		
(b) Free of poisonious compounds such as cyanide.		
b. Holding and heat-resisting compound	34. Pass out sample of holding and heat-resisting compound	30. Exam. Sample of holding and heat-resistir compound.
(1) Primary use		
(a) Holding irregular shapes or parts during welding brazing of soldering.		
(b) Protects threads and flammable materials from heat of flame arc or spatter.		
(2) Characteristics		
(a) Can be used over many times by mixing with a small amount of water.		
(b) Easily removed from holes or threads		
(c) Will not melt, burn, crack, expand or contract when heated.		
c. Molecular metal	35. Show contents of molecular metal kit.	31. Examine contents of molecular metal kit.
(1) Primary use		
(a) Leaking pipes, tanks, radiators, refrigeration, sumps, gas mains, pumps, valves, etc.		
(2) Secondary use		
(a) Joining metals to glass, wood, concrete, stone and other substrates.		

OUTLINE OF INSTRUCTION

(3) Characteristics

(a) Grade #1: A spatula grade used for emergency repairs.
Grade #2: A brushable, fluid material used for coating.
Grade #3: A spatula grade paste used for permanent repairs

III. Application

A. Questions and Discussions:

1. Name five of the seven electrodes and rods for welding of steel

ANS: 6011, 6012, 7018, 11018, 312-16 Stainless, E-70S3 MIG. triple deoxidized rod.

2. How many brazing rods are there in the T.O.A. and which one is the lowest temperature?

ANS: Four; silver brazing, general brazing, hi-strength brazing and arc brazing. Silver brazing is the lowest temperature.

3. What should be used to seal a leak in a gas tank?

ANS; Molicular metal

4. Name the wearfacing electrodes in the T.O.A.

ANS: Build up, manganese, intermediate wearfacing and high abrasion resistant.

5. Which solder should be used on food containers

ANS: 96/4 tin-silver

INSTRUCTOR ACTIVITY

36. Ask questions to check students comprehension

STUDENT ACTIVITY

32. Answer questions.

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OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

6. What should be used to harden the threads on a bolt?

ANS: Case-hardening compound

7. What welding material should be used to join an extension on a drill bit?

ANS: Hi-strength brazing rod

8. What material should be used to weld a manifold?

ANS: Cast iron gas (flux-coated)

9. What steel welding rod can be used for cutting?

ANS: 6011

10. What kind of flux core solder should be used on electrical work?

ANS: Rosin core.

IV. SUMMARY

A. Welding Consumables

1. Arc welding electrodes

a. Steel

(1) 6011

(2) 6012

(3) 7018

(4) 11018

(5) E70S3 (MIG)

(6) 312-16 (Stainless)

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
b. Aluminum		
(1) 4043 (Stick)		
(2) 5356 (MIG)		
c. Cast iron		
(1) Nickel base		
(2) Nickel-iron base		
d. Brazing		
(1) Arc brazing		
e. Chamfering		
(1) Chamfer rod		
f. Carbon		
(1) Carbon electrode		
2. Gas welding rods		
a. Mild steel		
(1) Triple deoxidized rod		
b. Cast iron		
(1) Cast iron (flux-coated)		
c. Brazing		
(1) General brazing		
(2) High-strength brazing		116
(3) Silver brazing		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
d. Solder		
(1) Tin - Antimony 95/5		
(2) Tin - Lead 50/50		
(3) Tin - Lead 40/60 - Acid core		
(4) Tin - Lead 60/40 - Rosin core		
(5) Tin - Silver 96/4		
3. Wearfacing electrodes		
a. Manganese		
b. Build up		
c. Intermediate wearfacing		
d. High abrasion wearfacing		
4. Welding aids		
a. Case-hardening compound		
b. Holding and heat-resisting compound		
c. Molecular metal		
V. TEST: None		
VI. ASSIGNMENT:	37. Post assignment on chalkboard	33. Copy assignment
A. Operator's Manual Welding Theory and Application", TM9-237, Chapter 2, pages 5 through 12.		

NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043
STEELWORKER STT SCHOOL TRAINING COURSE 615-2

Classification: Unclassified

Topic: Annealing, Hardening and Tempering

Average Time: Class: 3 periods
Pract: 2 periods

Instructional Materials:

A. Training Aids: None

B. Publications:

1. Text

   a. "Operator's Manual Welding Theory and Application" TM9-237 pages 14-18.

   b. Welding Encyclopedia" 16th edition pages H-15, H-16.

2. Reference: None

C. Equipment and Materials:

1. Oxy-Mapp Welding Outfit

D. Instructor Preparirad Material (Local); None

Terminal Objective: 1.2.

Enabling Objective: Upon completion of this topic the student will have.

1. Defined the term anneal and list four purposes of the process.
2. Defined hardening in terms of work, flame and case hardening.
3. Stated the definition of tempering and it's purpose. All will be without error.

Criterion Test:

The student will define the term anneal and list four purposes of the process. Define hardening in terms of work, flame and case hardening. State the definition of tempering and it's purpose. All will be without error.

Homework: None

Homework:

OUTLINE OF INSTRUCTION	**INSTRUCTOR ACTIVITY**	**STUDENT ACTIVITY**
I. Introduction to the Lesson	1. Introduce self and topic.	
A. Establish contact.		
1. Names:		
2. Topic: Annealing, Hardening and Tempering		
B. Establish readiness	2. Motivate student.	
1. Purpose		
2. Assignment		
C. Establish effect	3. Bring out need and value of material being presented.	
1. Value		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better steelworker		
D. Overview:	4. State learning objectives.	
1. Annealing		
2. Hardening	a. State information and materials necessary to guide student.	
3. Tempering		

OUTLINE OF INSTRUCTION

II. PRESENTATION

A. Annealing

1. Remove stresses

a. Castings

(1) Castings with original residual stresses.

(a) Castings with thick and thin sections

(2) Previously welded castings - prior to rewelding.

b. Weldments

(1) Enabling greater load before deforming or cracking

NOTE: Make use of the stress-strain diagram to illustrate combined residual and welding stressess.

c. Machining weldments

(1) Weldments can distort while being machined unless first stress relieved after welding.

d. Procedure

(1) Uniform heating

(2) Allow one hour soaking time for each one inch of thickness.

2. Induce softness

a. Machinablility

(1) Cast iron (welding forms iron carbides).

(2) Medium and high-carbon steel

(3) Tool steel

INSTRUCTOR ACTIVITY

5. Draw diagrams on chalkboard of different shapes of castings and explain how stress forms due to different cooling rates.

6. Draw on chalkboard diagrams of welded castings and how contractional stress forms.

7. Use slide on stress strain diagram to illustrate strain relationships.

8. Draw diagram on chalkboard on how stress goes to top of weld and when machined off will cause distortion unless stress is relieved.

STUDENT ACTIVITY

1. Take notes

2. Ask questions

OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

b. Remove work hardening

(1) Parts subject to stress and vibration.

Example: Brake lines and copper fuel lines work harden at bends.

3. Alters ductility

a. Annealing returns ductile requirements.

(1) Increases ability to be drawn or stretched.

4. Alters toughness

a. Enables weldments to withstand greater shock.

(1) Will resist fracture after permanent deformation has begun.

5. Alters electrical conductivity

a. Work-hardened copper or aluminum offers greater electical resistance.

6. Refines crystalline structures

a. Refining from coarse-grain structure improves physical properties.

7. Removes gases

a. Annealing permits slow gas release from castings.

8. Changes microstructure

a. Slow cooling produces spheroidized carbide.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
B. Hardening		
1. Work hardening		
a. Methods		
(1) Peening - hammering		
(2) Bending	9. Bend wire to illustrate how it work hardens	
(a) Example: Bend a copper or steel wire until it work hardens.		
Note; The wire will become hot at the point of bend indicating the friction of the grains against each other.		
Use the stress-strain diagram to show area of work hardening which causes increased hardness and strength.		
(3) Drawing		
(a) Example: Reducing wire rod or tubing size by drawing through a die.		
(4) Cold rolling		
(a) Sheet, plate, etc.		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

2. Flame hardening

   a. Definition: Heating the surface of a ferrous material to a high temperature followed by a rapid quench.

   b. Advantages

      (1) Hardness limited to a thin casing.

         (a) Core retains ductility, toughness and resistant to impact.

      (2) Machined surface retains dimension.

      (3) Large objects can be flame-hardened.

      (4) Flame hardened areas may be made as small or as large as desired.

      (5) Adaptable to a variety of shapes and sizes

      (6) Limited time required.

      (7) Almost entirely free of distortion.

   c. Quenching solutions

      (1) Water

      (2) Brine

      (3) Oil

      (4) Air

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OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

3. Case hardening (with torch)

   a. Definition: Carburizing and subsequent hardening by suitable heat treatment all or part of the surface portions of an iron-base alloy.

   b. Advantages

      (1) Hardness limited to a thin casing

         (a) Core retains ductility, toughness and resistance to impact.

      (2) Machined surface retains dimension

      (3) Mild steel may be hardened

      (4) Limited time required

      (5) Selective case hardening

      (6) Case hardening material is safe to use because it is cynide free.

   c. Quenching solutions

      (1) Clean cold water

   d. Examples of items to case harden

      (1) Chisels and punches. (use mild steel)

      (2) Threads on bolts, nuts, etc.

      (3) Pins

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
C. **Tempering (Drawing)**		
1. **Definition: The reheating of iron-base alloys after hardening to some temperature below the critical range followed by any desired rate of cooling.**		
2. **Advantages**		
a. Imparts toughness to the steel.		
Note: In the hardened condition steels tend to be brittle and have low resistance to shock, but if reheated (tempered) they are softened somewhat and toughened. The higher the tempering temperature, the greater the toughness and the lower the hardness .		
III. **APPLICATION**		
A. Questions and Discussion	10. Ask questions	3. Answer questions
1. Name four purposes for annealing.		
ANS: a. Remove stresses b. Induce softness c. Alter ductility d. Alter toughness e. Alter elctrical conductivity f. Refine crystalline structure g. Remove gases from castings h. Change microstructure		

2. What are the three ways to harden metal in the field?

ANS: a. Work hardening

b. Flame hardening

c. Case hardening (with hardeing compound)

3. Tempering impacts what property to hardened steel?

ANS: Toughness

4. How can metal be hardened without heat?

ANS: a. Work hardened

(1) Peening - hammering

(2) Bending

(3) Drawing

(4) Cold-rolling

5. What is the main advantage of case hardening?

ANS: The surface obtains a high hardness but the core retains ductility, toughness and resistance to impact.

IV. SUMMARY

A. Annealing

1. Remove stresses

2. Induce softness

3. Alter toughness

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
4. Alter ductility		
5. Alter electrical conductivity		
6. Refine crystalline structure		
7. Remove gases		
8. Change microstructure		
B. Hardening		
1. Work hardening		
2. Flame hardening		
3. Case hardening		
C. Tempering		
1. Toughness		
V. TEST	11. In shop demonstrate annealing, hardening, and tempering.	
A. Annealing		
B. Hardening and Tempering	12. Supervise student practice and test.	4. Practice under instructors supervision.
C. Case Hardening		5. Take test
VI. ASSIGNMENT: None		

NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043

STEELWORKER STT SCHOOL TRAINING COURSE 615-2
GAS CUTTING/WELDING II

Classification: **Unclassified**

Topic: **Gas Welding Pipe, Vertical Position**

Average Time: **Class: 1 period**
Pract: 5 periods

Instructional Materials:

A. **Text:**

1. **Steelworker 3 & 2, NAVPERS-10653-E., Chapter 6.**

B. **References:**

1. **American Welding Society, standard for qualification of welding procedures and welders for piping and tubing AWS D-10, 9-72.**

2. **Operator's Manual Welding Theory and Application TM9-237.**

3. **The Welding Encyclopedia, 16th Edition .**

C. Instructional Material

1. Safety for welders (**information**sheet) IS-1.1.1.-1

2. Samples of pipes beveled, spaced and tacked.

3. Samples of pipes showing bead placement.

4. X-Rays showing defects in welds and good welds.

Terminal Objective: 2.1

Enabling Objective: Upon completion of this topic the student will be able to:

A. Perform correct techniques for welding pipe as to gage setting, type of flame, speed of travel, manipulation of torch and correct welding rod. Perform specified degree of cleaning of completed weld.

B. Demonstrate proper pipe preparation by beveling, cleaning, aligning, spacing and tack welding, prior to welding.

C. Gas weld with a 1/8" triple deoxidized rod a V-butt joint in the vertical position, (fixed) a 2" mild steel pipe. In doing this he will apply all pertinent safety precations as stipulated in IS-1.1.1.1 and identify and apply the correct procedure and methods of correcting faults. Evaluation will be based on the Qualification Test for AR-3 level, of American Welding Society, standard for Qualification of Welding Procedures and Welders for Piping and Tubing, AWS D10. 9-72 condensed in standard STT-FT-1 attached to this unit.

Criterion Test:

Evaluation will be based on the students ability to pass the visual and guided-bend test as stipulated above.

Homework: None

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D. Instructor Aids: None

E. Tools

1. Chipping hammer
2. Pliers, 8"
3. Gloves
4. Spark lighter
5, Tip cleaner

F. Equipment:

1. Oxy-Mapp Cutting and Welding Unit
2. Bench grinder
3. Pipe beveling machine

G. Materials:

1. Paper, lined scratch pad.
2. Pencils
3. Pipe, mild steel 2"
4. Oxygen
5. Mapp Gas
6. Triple Deoxidized Rod (steel gas rod)

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the Lesson A. Establish contact. 1. Names: 2. Topic: Pipe Welding (Vertical)	1. Introduce self and topic.	
B. Establish readiness 1. Purpose 2. Assignment	2. Motivate student.	
C. Establish effect 1. Value a. Pass course. b. Perform better on the job. c. Get advanced. d. Be a better steelworker	3. Bring out need and value of material being presented.	
D. Overview: 1. Gas weld a V-butt joint in the vertical fixed position (Practice)	4. State learning objectives. a. State information and materials necessary to guide student.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. PRESENTATION.		
A. Techniques of Pipe Welding (vertical fixed position)		
1. Adjust gages for beveling pipe		
a. Mapp		
b. Oxygen		
(1) Determined by		
(a) Size and thickness of pipe.		
2. Bevel pipe		
3. Remove scale		
4. Align pipe		
a. Spacing		
5. Tack Pipe		
a. Four tacks		
(1) Don't stop or start a weld on tacks		
6. Position pipe in vertical fixed posiiton		
7. Complete other side of pipe	5. Demonstrate welding a 2" pipe in the vertical fixed position.	1. Practice gas welding a 2" vertical fixed pipe.
8. Do not stir puddle with rod		
9. Do not agitate puddle with flame		
10. Clean scale from weld		

OUTLINE OF INSTRUCTION

B. Faults in gas welding

1. Porosity
2. Undercut
3. Overlap
4. Poor fusion
5. Incomplete penetration
6. Warpage

III. APPLICATION:

A. Insert questions to check students comprehension.

IV. SUMMARY:

A. Single V-butt vertical fixed pipe weld.

V. TEST: None

INSTRUCTOR ACTIVITY

6. Explain reasons for faults in welding.

STUDENT ACTIVITY

NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043

STEELWORKER STT SCHOOL TRAINING COURSE 615-2
GAS CUTTING/WELDING II

Classification: **Unclassified**

Topic: **Practical Evaluation in Gas Welding Pipe, Vertical Fixed Position.**

Average Time: **Class: 0 periods**
Pract: 2 periods

Instructional Materials:

A. Text: None

B. References: None

C. Tools:

1. Chipping hammer
2. Plers 8"
3. Gloves
4. Spark lighter
5. Tip cleaners

D. Equipment:

1. Oxy-Mapp cutting & welding unit
2. Bench grinder
3. Pipe beveling machine

Terminal Objective: 2.1

Enabling Objective: Upon completion of this topic the student will be able to:

A. Perform correct techniques for welding pipe as to gage setting, type of flame, speed of travel, manipulation of torch and correct welding rod. Perform specified degree of cleaning of completed weld.

B. Demonstrate proper pipe preparation by beveling, cleaning, aligning, spacing and torch welding, prior to welding.

C. Gas weld with a 1/8" triple deoxidized rod a V-butt joint in the vertical fixed position a 2" mild steel pipe. In doing this he will apply all pertinent safety precatuions as stipulated in IS-1.1.1.1 and identify and apply the correct procedure and methods of correcting faults. Evaluation will be based on the Qualification Test for AR-3 level of American Welding Society standard for Qualification of Welding procedures and Welders for Piping and Tubing, AWS D10. 9-72 condensed in standard STT-FT-1 attached to this unit. The final weld must meet the minimum requirements established for gas welding pipe in the vertical fixed non-restricted position

Criterion Test:
Evaluation will be based on the students ability to pass the visual and guided-bend test as stipulated above.

Homework: None

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E. Materials:

1. Pipe, mild steel 2"
2. Oxygen
3. Mapp Gas
4. Triple deoxidized Rod (steel Gas rod)

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OUTLINE OF INSTRUCTION	**INSTRUCTOR ACTIVITY**	**STUDENT ACTIVITY**
I. Introduction to the Lesson A. Establish contact. 1. Names 2. Topic: Pipe Welding (Vertical) Evaluation	1. Introduce self and topic.	
B. Establish readiness 1. Purpose 2. Assignment	2. Motivate student.	
C. Establish effect 1. Value a. Pass course. b. Perform better on the job. c. Get advanced. d. Be a better steelworker	3. Bring out need and value of material being presented.	
D. Overview: 1. Gas weld a V-butt joint in the vertical fixed position for evaluation	4. State learning objectives. a. State information and materials necessary to guide student.	

OUTLINE OF INSTRUCTION

II. PRESENTATION

A. Practical evaluation for vertical fixed position pipe welding.

1. Introduce test
    a. Nature of test
    b. Purpose of test.
2. Directions for Test
    a. Project to be completed
    b. Time alloted
    c. How graded
        (1) Appearance
        (2) Undercut
        (3) Overlap
        (4) Guided-Bend Test
3. Evaluating the completed weld.

INSTRUCTOR ACTIVITY

5. Stress the importance of neatness.
6. For testing, a completed test piece can only be evaluated.
7. Have test pipe cut, beveled and letter stamped prior to practical test time.
8. Stress that pipe will not be turned for welding during test.

STUDENT ACTIVITY

1. Make a single V-butt vertical fixed pipe weld for evaluation.

NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043

STEELWORKER STT SCHOOL TRAINING COURSE 615-2
GAS CUTTING/WELDING II

Classification: **Unclassified**

Topic: **Gas Welding Pipe, Horizontal fixed position.**

Average Time: **Class: 0 periods**
Pract: 5 periods

Instructional Materials: **None**

A. **Text: None**

B. **References: None**

C. Instructor Aids: None

D. Tools:

1. Chipping hammer
2. Pliers 8"
3. Gloves
4. Spark lighter
5. Tip cleaners

E. Equipment:

1. Oxy-Mapp Cutting and Welding Unit
2. Bench Grinder
3. Pipe Beveling Machine

Terminal Objective: **2.1**

Enabling Objective: Upon completion of this topic the student will be able to:

A. Perform correct techniques for welding pipe as to gage setting, type of flame, speed of travel, manipulation of torch and correct welding rod. Perform specified degree of cleaning of completed weld.

B. Demonstrate proper pipe preparation by beveling, cleaning, aligning, spacing and tack welding, prior to welding.

C. Gas weld, with a 1/8" triple deoxidized rod, a V-butt joint in the horizontal fixed position a 2" mild steel pipe. In doing this he will apply all pertinent safety precautions as stipulated in IS-1.1.1.1. and identify and apply the correct procedures and methods of correcting faults. Evaluation will be based on the Qualification Test for AR-3 level of American Welding Society, Standard for Qualification of Welding Procedures and Welders for Piping and Tubing, AWS D10. 9-72 condensed in standard STT FT-1 attached to this unit.

Criterion Test:
Evaluation will be based on the students ability to pass the visual and guided-bend test as stipulated above.
Homework: None

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F. Materials:

1. Pipe, mild steel 2"
2. Oxygen
3. Mapp Gas
4. Triple Deoxidized Rod (steel gas rod)

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the Lesson	1. Introduce self and topic.	
A. Establish contact.		
1. Names		
2. Topic: Pipe welding (Horizontal)		
B. Establish readiness	2. Motivate student.	
1. Purpose		
2. Assignment		
C. Establish effect	3. Bring out need and value of material being presented.	
1. Value		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better steelworker		
D. Overview:	4. State learning objectives.	
1. Gas weld a V-butt joint in the horizontal fixed position (practice)	a. State information and materials necessary to guide student.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. PRESENTATION		
A. Techniques of pipe welding (horizontal fixed position)	5. Bevel pipe ahead on pipe beveling machine but permit student to operate machine after demonstration.	
1. Adjust gages for beveling pipe.		
a. Mapp		
b. Oxygen		
(1) Determined by:		
(a) Size and thickness of pipe		
2. Bevel pipe		
3. Remove scale		
4. Align pipe	6. Stress the importance of proper alignment.	1. Remove scale
a. spacing		2. Align pipe a. spacing
5. Tack pipe	7. Demonstrate tacking of pipe.	
a. Four tacks	a. Four small tacks	3. Tack Pipe
(1) Dont stop or start welds on tacks		4. Position pipe
6. Position pipe in vertical fixed position		
7. Start weld at 7 o'clock and weld toward 6 o'clock on the position of the pipe and weld 1/2" pas 12 o'clock Then finish weld by starting at 7 o'clock and finish weld.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
8. Do not stir puddle with rod		5. Practice gas welding 2" vertical fixed pipe
9. Do not agitate puddle with flame		
10. Clean scale from weld.		
B. Faults in gas welding	8. Explain reasons for faults in welding.	
1. Porosity		
2. Undercut		
3. Overlap		
4. Poor fusion		
5. Incomplete penetration		
6. Warpage		
III. APPLICATION:		
A. Insert questions to check student comprehension		
IV. SUMMARY:		
A. Single V-butt horizontal fixed pipe weld		
V. TEST: NONE		

NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043

STEELWORKER STT SCHOOL TRAINING COURSE 615-2
GAS CUTTING/WELDING II

Classification: **Unclassified**

Topic: **Practical Evaluation in Gas Welding Pipe, Horizontal Fixed Position.**

Average Time: **Class: 0 periods**
Pract: 2 periods

Instructional Materials: None

A. TEXT: None

B. References: None

C. Instructional Aids: None

D Tools:

1. Chipping hammer
2. Pliers
3. Gloves
4. Spark lighter
5. Tip cleaners

E. Equipment:

1. Oxy-Mapp Cutting and Welding Unit
2. Bench Grinder
3. Pipe beveling machine.

Terminal Objective: 2.1

Enabling Objective: Upon completion of this topic the student will be able to :

A. Perform correct techniques for welding pipe as to gage setting, type of flame, speed of travel, manipulation of torch and correct welding rod. Perform specified degree of cleaning of completed weld.

B. Demonstrate proper pipe preparation by beveling, cleaning, aligning, spacing and tack welding, prior to welding.

C. Gas weld with a 1/8" triple deoxidized rod a V-butt joint in the horizontal fixed position a 2" mild steel pipe. In doing this he will apply all pertinent safety precautions as stipulated in IS-1.1.1.1 and identify and apply the correct procedures and methods of correcting faults. Evaluation will be based on the Qualification Test for AR-3 level of American Welding Society Standard for Qualification of Welding Procedures and Welders for Piping and Tubing, AWS D10. 9-72 condensed in standard STT -FT-1 attached to this unit. The final weld must meet the minimum requirements established for gas welding pipe in the horizontal fixed non-restricted position

Criterion Test:

Evaluation will be based on the students ability to pass the visual and guided-bend test as stipulated above.

Homework: None

F. Materials:

1. Pipe, mild steel 2"
2. Oxygen
3. Mapp Gas
4. Triple deoxidized rod (steel gas rod)

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the Lesson	1. Introduce self and topic.	
A. Establish contact.		
1. Name:		
2. Topic: Pipe Welding (Horizontal) Evaluation.		
B. Establish readiness	2. Motivate student.	
1. Purpose		
2. Assignment		
C. Establish effect	3. Bring out need and value of material being presented.	
1. Value		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better steelworker		
D. Overview:	4. State learning objectives.	
1. Gas weld a V-butt joint in the horizontal fixed position for evaluation.	a. State information and materials necessary to guide student.	

OUTLINE OF INSTRUCTION

II. PRESENTATION

A. Practical evaluation for horizontal fixed position pipe welding.

1. Introduce test
   - a. Nature of test
   - b. Purpose of test
2. Directions for Test
   - a. Project to be completed
   - b. Time alloted
   - c. How graded
     - (1) Appearance
     - (2) Undercut
     - (3) Overlap
     - (4) Guided-Bend test
3. Evaluating the completed weld

INSTRUCTOR ACTIVITY

5. Stress the importance of neatness
6. For testing, a completed test piece can only be evaluated.
7. Have test pipe cut belved and letter stamped prior to practical test time.
8. Stress that pipe will not be turned for welding during test.

STUDENT ACTIVITY

1. Make a simple V-butt horizontal fixed pipe weld for evaluation.

NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043
STEELWORKER STT SCHOOL TRAINING COURSE 615-2

Classification:Unclassified

Topic: General Brazing

Average Time: Class: 1 period
Pract: 5 periods

Instructional Materials:

A. Training Aids:

B. Publications:

1. Texts: None

2. References:

a. "Brazing Manual" American Welding Society

C. Equipment and Materials:

1. Major equipment

a. Gas Welding Equipment

2. Tools

a. Gloves

b. Goggles

c. Pliers

d. Slag hammer

e. Spark lighter

f. Tip cleaners

Terminal Objective: 2.2

Enabling Objective: Upon completion of this topic the student will be able to:

A. Bronze weld a single vee butt joint of mild steel 3/16" x 4" with an Oxy-gas torch in the flat positio

B. Bronze weld a tee joint of mild steel 3/16" x 4" with an Oxy-gas torch in the flat position.

C. Bronze weld a lap joint of mild steel 3/16" x 4" with an Oxy-gas torch in the flat position.

D. The above shall be done in accordance with SWC-FT-1.

Criterion Test:

The student will bronze weld a single vee butt joint of mild steel 3/16" x 4" with an OXY-gas torch in the flat position. Bronze weld a lap joing of mild steel 3/16" x 4" with any Oxy-gas torch in the flat position. Bronze weld a lap joint of mild steel 3/16" x 4" with an oxy-gas torch in the flat position. All will be in accordance with SWC-FT-1.

Homework: None

  - g. Wire brush

3. Materials
   - a. Brazing flux
   - b. Bronze Rod (flux coated)
   - c. Chalk
   - d. Mapp gas
   - e. Oxygen
   - f. Steel plate (mild) 3/16" x 4"

D. Instructor prepaired materials (Local) None

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OUTLINE OF INSTRUCTION

I. Introduction to the Lesson

- A. Establish contact.
  - 1. Name:
  - 2. Topic: General Brazing
- B. Establish readiness
  - 1. Purpose
  - 2. Assignment
- C. Establish effect
  - 1. Value
    - a. Pass course.
    - b. Perform better on the job.
    - c. Get advanced.
    - d. Be a better steelworker
- D. Overview:
  - 1. General Brazing (Mild steel)
    - a. Simple Vee butt
    - b. Tee joint
    - c. Lap joint

INSTRUCTOR ACTIVITY

1. Introduce self and topic.

2. Motivate student.

3. Bring out need and value of material being presented.

4. State learning objectives.

   a. State information and materials necessary to guide student.

STUDENT ACTIVITY

OUTLINE OF INSTRUCTION

II. PRESENTATION

A. General Brazing (mild steel) 3/16" x 4" x 6"

1. Single-vee butt

a. Preparation

(1) Sample plates 3/16" x 4" x 6" (30° bevel)

(2) Grind or file joint area. (Do not wire brush)

(3) Alignment of beveled joint. (1/16" root opening)

b. Tacking

(1) Place a small tack weld at each end of joint. (Get good penetration)

c. Fluxing

(1) Apply flux over entire joint area.

d. Preheat

(1) Preheat entire joint area.

Note: Proper preheat is obtained when flux remains liquid when torch is removed from plate-keep flame off of flux.

INSTRUCTOR ACTIVITY

5. Draw diagrams on the chalkboard of the three types of joints and the confiquration of the bronze deposits.

STUDENT ACTIVITY

1/ Take notes

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
e. Bronze welding		
(1) First pass		
(a) Complete penetration		
(b) Tin bevel ahead of bead		
(c) Fuse in tack welds		
(2) Second pass		
(a) Tin ahead of bead		
(b) Proper fusion into first pass		
(c) Final pass is to be unifrom and smooth		
f. Post heat		
(1) Bring test plates to uniform temperature		
g. Cleaning		
(1) Quench after plate temperature drops below 700° F		
(2) Completely remove all flux by chipping and wire brushing.		
Note: Protect hands and eyes when cleaning off flux - it will cut like glass.	6. Stress safety	

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

2. Tee joint

   a. Preparation

      (1) Sample plates 3/16" x 4" x 6" (no bevel).

      (2) Grind or file joint area. (Do not wire brush)

      (3) Alignment of tee joint. (no gap)

   b. Tacking

      (1) Place a small tack weld at each end edge of vertical plate

   c. Fluxing

      (1) Apply flux over entire joint area. (Note - make sure flux penetrates joint).

   d. Preheat

      (1) Preheat entire joint area.

      Note: Proper preheat is obtained when flux remains liquid when torch is removed from plate - keep flame off of flux.

   e. Bronze welding

      (1) First pass

         (a) Complete penetration of tee joint

         (b) Tin joint ahead of bead

         (c) Fuse in tack welds.

7. Stress the importance of good tinning of joint.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

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(2) Second pass

(a) Tin ahead of bead

(b) Proper fusion into first pass

(c) Final pass is to be uniform and smooth

Note: Bronze weld is to be made only on one side of tee joint for test specimen .

f. Post heat

(1) Bring test plates to uniform temperature.

g. Cleaning

(1) Quench after plate temperature drops below 700° F.

(2) Completely remove all flux by chipping and wire brushing

Note: Protect hands and eyes when cleaning off flux - it will cut like glass.

3. Lap joint

a. Preparation

(1) Sample plates 3/16" x 4" x 6" (no bevel)

(2) Grind or file joint area.) Do not wire brush)

(3) Alignment of lap joint (5/16" lap - no gap)

OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

b. Tacking

(1) Place a small tack weld at each end on edge of lap joint.

c. Fluxing

(1) Apply flux over entire joint area.

Note: Make sure flux penetrates joint.

d. Preheat

(1) Preheat entire joint area

Note: Proper preheat is obtained when flux remains liquid when torch is removed from plate. Keep flame off of flux.

e. Bronze welding

(1) First pass

(a) Penetrate brazing material into lap joint

(b) Tin ahead of bead

(c) Fuse in tack welds

(2) Second pass

(a) Tin ahead of bead

(b) Proper fusion into first pass

(c) Final pass is to be uniform and smooth

Note: Bronze weld is to be made only on one side of tee joing for test specimen.

OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

f. Post heat

(1) Bring test plates to uniform temperature.

g. Cleaning

(1) Quench after plate temperature drops below 700° F.

(2) Completely remove all flux by chipping and wire brushing.

Note: Protect hands and eyes when cleaning off flux - it will cut like glass. Insure that there is proper ventilation for the flux and zinc fumes and that the student does not position his face directly over the work.

III. APPLICATION:

A. Questions and Discussion

1. Why is preparation of a joint to be brazed, not wire brushed?

ANS: Wire brushing may deposit foreign matter, such as grease, on the weld area and not remove the mill scale.

2. Why is a stronger joint obtained by first grinding or filing a joint?

ANS: Filing and especially grinding will leave grooves for the filler metal to lock into.

3. In preheating why should the flame be kept off the flux?

ANS: The flame could burn the flux.

4. Why is uniform post heat necessary?

ANS: To prevent residual stresses

5. Why is brazing flux more hazardous to remove than slag?

ANS: It will cut like glass.

OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

IV. SUMMARY:

A. General Brazing (mild steel) 3/16" x 4"

1. Single-vee butt
   - a. Preparation
   - b. Tacking
   - c. Fluxing
   - d. Preheat
   - e. Bronze welding
   - f. Post heat
   - g. Cleaning

2. Tee joint
   - a. Preparation
   - b. Tacking
   - c. Fluxing
   - d. Preheat
   - e. Bronze welding
   - f. Post heat
   - g. Cleaning

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
3. Lap joint		
a. Preparation		
b. Tacking		
c. Fluxing		
d. Preheat		
e. Bronze welding		
f. Post heat		
g. Cleaning	7. Students to practice brazing at individual pace under supervision of instructor.	2. Practice brazing at individual pace under supervision of the instructor.
V. TEST:		
A. Practical Test (General Brazing - Mild Steel)		
1. Single-vee butt		
2. Tee joint		
3. Lap joint		
VI. ASSIGNMENT		
A. "Operator's Manual Welding Theory and Application" TM9-237, Chapter 2, Pages 6 through 12.	8. Past assignment on chalkboard.	

NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043

STEELWORKER STT SCHOOL TRIAING COURSE 615-2

Classification: Unclassified

Topic: Soft Soldering

Average Time: Class: 1 period
Pract: 4 periods

Reference: A. Naval Construction Force Safety Manual COMCBPAC/ COMCBLANT INST. 5100.1

Text: A. NAVPERS 10653-E Steelworker 3&2 pp. 284-292

Instructional Materials:

A. Films:

1. MN-7831-I The Use of Soldering Coppers (8 min.)
2. MN-9753 "On Solder" (25 min) obsolete

B. Transperencies: None

C. Actual finished samples of various projects.

Instructional Aids:

A. 16 MM movie projector

Tools:

A. Soldering coppers

Terminal Objective: 2.2

Enabling Objective: Upon completion of this topic the student will be able to:

A. Select proper soldering copper, flux and solder for the metal to be soldered.

B. Solder sheet metal by preparing the metal and soldering coppers prior to soldering common metals used in the sheet metal shop.

C. All safety precautions and practices must be observed. Completed projects must not exceed a tolerance of 1/8 inch plus or minus on any given measurement.

Criterion Test: When shown the various types of soldering coppers the student will identify each by it's correct name and characteristic; Select proper flux and solder for the metal to be soldered; Soldered sheet metal by preparing metal and soldering coppers prior to soldering metals used in the sheet metal shop. All safety precatutions and practices must be observed. Completed projects must not exceed a tolerance of 1/8 inch plus or minus on any given measurement, and conform to standards as stipulated in SWC-FT-1

Homework:

A. Reading assignment NAVPERS 10653-E Steelworker 3&2 Pages 372-385

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Equipment:

A. Shears

B. Brake.

Materials:

A. Sheet metal

B. Solder

C. Rags

D. Fluxes

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the Lesson	1. Introduce self and topic.	
A. Establish contact.		
1. Name:		
2. Topic: Soft Soldering and metal layout		
B. Establish readiness	2. Motivate student.	
1. Purpose		
2. Assignment		
C. Establish effect	3. Bring out need and value of material being presented.	
1. Value		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better steelworker		
D. Overview:	4. State learning objectives.	
1. Objectives		
2. Notes	a. State information and materials necessary to guide student.	
3. Questions		
4. Testable		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. PRESENTATION		
A. Soldering equipment.		
1. Soldering coppers (irons)		
a, Made of copper for high heat conductivity		
b. Supplied in pairs.		
(1) One to use and one being preheated		
(2) A four pound copper is actually two-two pound coppers.		
c. Supplied in various forms and shapes for specified jobs		
(1) Pointed - for general work		
(2) Stub - for sweating seams that requires concentrated heat		
(3) Bottom - for bottom of pails, pans, etc., in restricted space.		
2. Electric irons		
a. Best for shop work	6. Show film MN-7831-1 "The use of soldering coppers".	2. Watch film
b. Supplied in various forms and shapes for specific jobs.		
c. Designated by watts.	7. Discuss key point of movie	3. Discuss film

OUTLINE OF INSTRUCTION

B. Fluxes

1. Corrosive

a. Zinc chloride

(1) Obtained by cutting raw hydrochloric (muriatic) acid

(2) Break down oxides on the metal

(3) Forms protective coating on metal to prevent oxidation.

(4) Melts at about 354° F which is slightly below melting point of most soft solders.

(5) Used on galvanized steel or zinc.

b. Ammonium chloride (Sal Ammoniac).

(1) Seldom used as a flux by itself because of high corrosive action.

(2) Fumes are toxic and should not be breathed.

(3) Used for:

(a) Tinning flux for soldering coppers.

(b) Iron and steel

(4) Comes in cake or powder form

c. Hydrochloric acid

(1) Used raw or cut with water.

INSTRUCTOR ACTIVITY

8. Random questioning to class to check comprehension.

STUDENT ACTIVITY

OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

NOTE: Alwasy pour acid into water - Never water into acid.

(2) Use on galvanized surfaces

(3) Combined with acetic acid or various other elements for fluxing stainless steel, monel and other high nickel alloys.

d. Phosphoric acid

(1) Excellent flux for stainless steels and other nickel alloys.

e. Stearine

(1) Used on special alloys and metals

(a) Aluminum

(b) Stainless steel

NOTE: All corrosive fluxes must be removed after soldering due to high corrosive actions of the flux.

2. Non-corrosive fluxes

a. Rosin

(1) Effective only on light, very clean work, copper or copper alloys, or pretinned ferrous metals

(2) Not suited for heavy work requiring more heat

(a) Because it carbonizes at a low temperature

(3) Does not remove oxidation already present

(4) Does prevent heat oxidation during soldering

(5) Used mostly on electrical work or any work that flux cannot be removed after soldering.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

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b. Tallow

(1) Not used as a flux since discovery of more effective methods

(2) Used on fusion welding and soldering of lead

C. Composition of soft solders

1. Alloys of lead, tin and antimony

a. About 50% tin , 50% lead with very small amount of antimony is the most common

b. Melting point about 361° to 596° F

c. Available in three grades

(1) Grade 1 - fine solder

(a) Over 55% tin

(b) Melting point approximately 365° F

(c) Used on electrical work

NOTE: When a tin lead alloy is referred to as 50-50 40-60, or 60-40, etc., the tin is always indicate first and lead second.

(2) Grade 2 - medium solder

(a) 50-50 solder - 50% tin, 50% lead

(b) Melting point approximately 450° F.

(c) Used on electrical work, not as good as Grade 1.

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

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(3) Grade 3 - common solder

(a) Over 55% lead

(b) Melting point approximately 500° F.

(c) Used by plumbers for wiping joints.

NOTE: When antimony content is 0.5% or less in a solder it may be used, except in very special cases, for the same applications as the straight tin lead solders.

D. Soft Solders (available shapes).

1. Wire - can be with or without acid or rosin core.

2. Bar - has no core

E. Application of soft solders

1. Base metals

a. Must be clean

b. Must be tinned (thin coating of solder on tip)

c. Must be proper temperature

(1) Too much heat will cause excessive oxidation of base metal also burns tinning off soldering coppers

3. Use the proper flux. Most metals require a different flux.

4. When using a torch

a. Heat the base metal, never the solder

(1) Heat from the base metal will melt the solder

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
III. APPLICATION		
A. Student under supervision will layout and favricate the various projects assigned by the instructor.	9. Assign projects to students and supervise work performed by students.	4. Layout and fabricate various soldered joint under supervision of the instructor.
B. Prior to completion of application clean up work area.	10. Stress importance of good housekeeping	
IV. SUMMARY		
A. Soldering equipment		
1. Soldering coppers		
2. Electric irons		
B. Fluxes		
1. Corrosive		
a. Zinc chloride		
b. Ammonium chloride (Sal Ammoniac)		
c. Hydrochloric acid		
d. Phosphoric acid		
e. Stearine.		
2. Non-Corrosive		
a. Rosin		
b. Tallow		

OUTLINE OF INSTRUCTION

C. Composition of soft solders

   1. Alloys of tin and lead

   2. Alloys of lead, tin and antimony

   3. Miscellaneous types of solder

D. Soft solder (availabel shapes)

   1. Wire

   2. Bar

E. Application of soft solders

   1. Base metal preparation

   2. Soldering coppers

   3. Proper flux

   4. Use of torch

F. Sheetmetal layout - practical

   1. Equipment

V. TEST

   A. Practical- sheet metal soldered joints

   B. Written at end of unit

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043
STEELWORKER STT SCHOOL TRAINING COURSE 615-2

Classification: Unclassified

Silver Brazing (Steel)

Average Time: Class: 1 period
Pract: 3 periods

Instructional Materials:

A. Training Aids: None

B. Publications:

1. Test: None

2. References:

    a. "Brazing Manual" American Welding Society

C. Equipment and Materials:

1. Major Equipment

    a. Gas welding equipment

2. Tools:

    a. Gloves

    b. Goggles

    c. Pliers

    d. Slag Hammer

Terminal Objective: 3.1

Enabling Objective: Upon completion of this topic the student will be able to:

A. Silver Braze a square butt joint of 1/8" x 1" x2" mild steel with an oxy-gas torch in the flat position

B. Silver Braze a tee joint of 1/8" x 1" x 2" mild steel with an oxy-gas torch in the flat position.

C. SilverBraze a lap joint of 1/8" x 1" x 2" mild steel with an oxy-gas torch in the flat position.

D. The above shall be done with a joint of .0015 to .003 with no build up.

Criterion Test:
The student will Silver Braze a square butt joint of 1/8" x 1" mild steel with an oxy-gas torch in the flat posiiton, Silver Braze a tee joint of 1/8" x 1" mild steel with an Oxy-gas torch in the flat position, Silver Braze a lap joint 1/8" x 1" mild steel with an oxy-gas torch in the flat position. The above shall be done with a joint of .0015 to .003 with no build up.

Homework:
Reading Assignment: "Operators Manual Welding Theory and application TM9-237 Chapter 3 pages 19-22

- e. Spark lighter
- f. Tip cleaners
- g. Wire brush

3. Materials
    - a. Chalk
    - b. Flux, Silver Braze
    - c. Mapp gas
    - d. Oxygen
    - d. Silver brazing alloy (Codmium free) 1/16"
    - f. Steel strip (mild) 1/8" x 1"

D. Instructor prepaired materials (Local) None

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the Lesson	1. Introduce self and topic.	
A. Establish contact.		
1. Name:		
2. Topic: Silver Brazing (Steel)		
B. Establish readiness	2. Motivate student.	
1. Purpose		
2. Assignment		
C. Establish effect	3. Bring out need and value of material being presented.	
1. Value		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d Be a better steelworker		
D. Overview:	4. State learning objectives.	
1. Silver Brazing (steel) 1/8" x 1" x 2"	a. State information and materials necessary to guide student.	
a. Square butt		
b. Tee joint		
(1) Flat		
(2) Vertical		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Lap joint		
(1) Flat		
(2) Vertical		
II. PRESENTATION		
A. Silver Brazing (Steel) 1/8" x 1" x 2"	5. Draw diagram on the chalkboard of the three types of joints and the disposition of the alloy in the joints.	1. Take notes
1. Square-butt joint (flat)		
a. Preparation		
(1) Sample strips 1/8" x 1" x 2"		2. Ask questions when in doubts
(a) No bevel - only remove sharp top corner edge of both butting sides of strips with a file. This will permit alloy to penetrate into closefitting joint instead of spreading over top sides of strips.		
(2) Grind, file or sand paper joint area. (Do not use a wire brush)		
Note: Do not use aluminum-oxide emery paper.		
b. Positioning		
(1) Alignment of joint (no gap) hold strips in place by use of fire bricks, etc. - do not tack.		
c. Fluxing		
(1) Apply flux over entire joint area.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
d. Preheat		
(1) Preheat entire joint area.		
Note: Proper preheat is obtained if flux remains liquid when torch is removed from plate. Keep flame off of flux.		
e. Brazing		
(1) Feed brazing alloy into joint until alloy no longer disappears from top edge. Complete penetration must be obtained.		
Note: If alloy smokes, too much heat is being applied.		
(2) No build-up bead is required		
f. Post heat		
(1) Bring test strips to uniform temperature		
g. Cleaning		
(1) Quench after test strips temperature drops below 700° F.		
(2) Completely remove all flux by chipping and wire brushing.		
Note: Protect hands and eyes when cleaning off flux - it will cut like glass	6. Stress safety	

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OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

2. Tee joint (flat)

   a. Preparation

      (1), Sample strips 1/8" x 1" x 2"

      (2) Grind, file or sandpaper joint area. (Do not use a wire brush)

      Note: Do not use aluminum-oxide emery paper.

   b. Positioning

      (1) Alignment of joint (no gap). Hold vertical strip in place by the use of a steel strip or rod (touching top edge of vertical strip and bench top) - Do not tack.

   c. Fluxing

      (1) Apply flux over entire joint area.

   d. Preheat

      (1) Preheat entire joint area.

      Note: Proper preheat is obtained if flux remains liquid when torch is removed from strips. Keep flame off of flux.

   e. Brazing

      (1) Feed brazing alloy into joint until alloy no longer disappears from fillet. Complete penetration must be obtained.

      Note: If alloy smokes, too much heat is being applied

      (2) Throat of fillet build-up must not exceed 1/32"

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OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

f. Post heat

(1) Bring test strips to uniform temperature

g. Cleaning

(1) Quench after test strips temperature drops below 700° F.

(2) Completely remove all flux by chipping and wire brushing.

Note: Protect hands and eyes when cleaning off flux - it will cut like glass.

3. Tee joint (vertical)

a. Preparation

(1) Sample strips 1/8" x 1" x 2"

(2) Grind, file or sandpaper joint area. (Do not use a wire brush)

Note: Do not use aluminum-oxide emery paper.

b. Positioning

(1) Alignment of joint (no gap). Hold strips in place by the use of fire bricks - Do not tack.

c. Fluxing

(1) Apply flux over entire joint area

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OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

d. Preheat

(1) Preheat entire joint area.

Note: Proper preheat is obtained if flux remains liquid when torch is removed from strips - Keep flame off of flux.

e. Brazing

(1) Feed brazing alloy from top end of joint and permit capillary and gravity action to fill the joint down vertical. Feed the alloy until it no longer disappears from fillet.

Note: If alloy smokes, too much heat is being applied.

(2) Throat of fillet build-up must not exceed 1/32"

f. Post heat

(1) Bring test strips to uniform temperature.

g. Cleaning

(1) Quench after test strips temperature drops below 700° F.

(2) Completely remove all flux by chipping and wire brushing.

Note: Protect hands and eyes when cleaning off flux - it will cut like glass.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

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4. Lap joint (flat)

a. Preparation

(1) Sample strips 1/8" x 1" x 2"

(2) Grind, file or sandpaper joint area. (Do not use a wire brush).

Note: Do not use aluminum-oxide emery paper.

b. Positioning

(1) Alignment of joint (no gap) Lap strips 1/4". Support top strip on its free end by a 1/8" scrap strip and hold down with a fire brick. (Do not tack)

c. Fluxing

(1) Apply flux over entire joint area, including between lap joint.

d. Preheat

(1) Preheat entire joint area.

Note: Proper preheat is obtained if flux remains liquid when torch is removed from strips. Keep flame off of flux.

e. Brazing

(1) Feed brazing alloy into joint until alloy no longer disappears. Complete penetration must be obtained.

Note: If alloy smokes, too much heat is being applied

(2) Throat of fillet buildup must not exceed 1/32"

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OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

f. Post heat

(1) Bring test strips to uniform temperature.

g. Cleaning

(1) Quench after test strips temperture drops below 700° F.

(2) Completely remove all flux by chipping and wire brushing.

Note: Protect hands and eyes when cleaning off flux - it will cut like glass

5. Lap joint (vertical)

a. Preparation

(1) Sample strips 1/8" x 1" x 2"

(2) Grind, file or sandpaper joint area. (Do not use wire brush)

Note: Do not use aluminum-oxide emery paper

b. Positioning

(1) Alignment of joint (no gap). Hold strips in place by the use of fire bricks. Lap strips 1/4" (Do not tack)

c. Fluxing

(1) Apply flux over entire joint area, including between lap joint.

d. Preheat

(1) Preheat entire joint area

Note: Proper preheat is obtained if flux remains liquid when torch is removed. Keep flame off of flux.

e. Brazing

(1) Feed brazing alloy from top end of joint and permit capillary and gravity action to fill the joint down vertical. Feed the alloy until it no longer disappears from fillet.

Note: If alloy smokes, too much heat is being applied.

(2) Throat of fillet build-up must not exceed 1/32"

f. Post heat

(1) Bring test strips to uniform temperature

g. Cleaning

(1) Quench after test strips temperature drops below 700° F.

(2) Completely remove all flux by chipping and wire brushing.

Note: Protect hands and eyes when cleaning off flux - it will cut like glass.

Insure that there is proper ventilation for the flux and metallic fumes and that the student does not posiiton his face directly over the work.

Silver brazing alloy is thinflowing and only the joint tolerance of .0015 to .003 should be filled with little or no build-up

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

III. APPLICATION

A. Questions and Discussion

1. What is the most desirable joint tolerance for a silver brazed joint?

ANS: .0015 to .003

2. How can it be determined when the joint is completely filled with alloy?

ANS: The alloy being fed into the joint will no longer disappear.

3. How can it be determined when the joint has reached the proper temperature for brazing.

ANS: The flux will remain liquid from the heat of the base metal.

4. Why shouldn't aluminum-oxide emery paper be used to prepare a joint for brazing?

ANS: The aluminum-oxide will remain on the part to be brazed and prevent the flow of the alloy.

IV: SUMMARY

A. Silver Brazing)steel) 1/8" x 1" x 2"

1. Square butt (flat)

   a. Preparation

   b. Positioning

   c. Fluxing

   d. Preheat

   e. Brazing

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

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  - f. Post heat
  - g. Cleaning
- 2. Tee joint (flat)
  - a. Preparation
  - b. Positioning
  - c. Fluxing
  - d. Preheat
  - e. Brazing
  - f. Post heat
  - g. Cleaning
- 3. Tee joint (vertical)
  - a. Preparation
  - b. Positioning
  - c. Fluxing
  - d. Preheat
  - e. Brazing
  - f. Post heat
  - g. Cleaning

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
4. Lap joint (flat)		
a. Preparation		
b. Positioning		
c. Fluxing		
d. Preheat		
e. Brazing		
f. Post heat		
g. Cleaning		
5. Lap joint (vertical)		
a. Preparation		
b. Positioning		
c. Fluxing		
d. Preheat		
e. Brazing		
f. Post heat		
g. Cleaning	7. Students will practice Silver brazing at an individual pace under supervision of the instructor.	2. Practice silver brazing at individual pace under supervision of the instructor.
V. TEST:		
A. Practical Test (Silver Brazing Steel)		
1. Square-butt joint		
2. Tee joint		
3. Lap joint		

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
VI. ASSIGNMENT		
A. "Operator's Manual Welding Theory and Application" TM9-237 Chapter 3. pages 19 through 22.	8. post assignment on the chalkboard	

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NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043

STEELWORKER SST SCHOOL TRAINING COURSE 615-2

Classification: Unclassified

Topic: Silver Brazing (Brass)

Average Time: Pract: 3 periods

Instructional Materials:

A. Training Aids: None

B. Publications:

1. Texts: None

2. References:

a. "Brazing Manual" American Welding Society

C. Equipment and Materials:

1. Major Equipment

a. Gas welding equipment

2. Tools

a. Gloves

b. Goggles

c. Pliers

d. Slag hammers

Terminal Objective: 3.1

Enabling Objective: Upon completion of this topic the student will be able to:

A. Silver Braze a square butt joint of 1/16" x 1" x 2" brass with an oxy-gas torch in the flat and vertical position.

B. Silver braze a tee joint of 1/16" x 1" x 2" with an oxy-gas torch in the flat and vertical position.

C. Silver braze a 1/4" lap joint of 1/16" x 1" x 2" brass with an oxy-gas torch in the flat and vertical position.

D. The above shall be done with a joint of .0015 to .003 and with no build up.

Criterion Test: The student will silver braze a square butt joint of 1/16" x 1" x 2" brass with an oxy-gas torch in the flat and vertical position, Silver braze a tee joint of 1/16" x 1" x 2" brass with an oxy-gas torch in the flat and vertical position, Silver braze a 1/4" lap joint of 1/16" x 1" x 2" brass with an oxy-gas torch in the flat and vertical position, All shall be done with a joint of .0015 to .003 and with no build up.

Homework: Reading Assignment

1. "The Welding Encyclopedia" 16th edition pages C-32, P-40 and- P-41.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
e. Spark lighter		
f. Tip cleaners		
g. Wire brush		
3. Materials		
a. Flux, Silver Brazing		
b. Mapp gas		
c. Oxygen		
d. Silver Brazing alloy (Cadmium free)		
e. Brass strip 1/16" x 1" x 2"		
D. Instructor Prepared Material (local): None		

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the Lesson	1. Introduce self and topic.	
A. Establish contact.		
1. Name:		
2. Topic: Silver Brazing (Brass)		
B. Establish readiness	2. Motivate student.	
1. Purpose		
2. Assignment		
C. Establish effect	3. Bring out need and value of material being presented.	
1. Value		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Steelworker		
D. Overview: 1. Silver Brazing (Brass)	4. State learning objectives.	
a. Square butt joint (flat)	a. State information and materials necessary to guide student.	
b. Tee joint (1) Flat position (2) Vertical position		
c. Lap joint (1) Flat position (2) Vertical position		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. PRESENTATION		
A. Silver Brazing (brass)		
1. Square-butt joint		
a. Preparation		
(1) Sample strips 1/16" x 1" x 2"	5. Stress removing sharp edges from brass strips	
b. Posiitoning		2. Ask questions when in doubt.
(1) Alignment of joint (no gap). Hold strips in place by use of fire bricks, etc. - Do not tack.		
c. Fluxing		
(1) Apply flux over entire joint area		
d. Preheat		
(1) Preheat entire joint area		
Note: Proper preheat is obtained if flux remains liquid when torch is removed from plate - keep flame off of flux.		
e. Brazing		
(1) Feed brazing alloy into joint until alloy no longer disappears from top edge. Complete penetration must be obtained.		
Note: If alloy smokes, too much heat is being applied		
(2) No buildup bead is required.		
f. Post heat		
(1) Bring test strips to uniform temperature.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
g. Cleaning		
(1) Quench after test strips temperature drops below 700° F.		
(2) Completly remove all flux by chipping and wire brushing.		
Note: Protect hands and eyes when cleaning off flux - it will cut like glass.	6. Stress the importance of sharp flux particles	
2. Tee joint (flat)		
a. Preparation		
(1) Sample strips 1/16" x 1" x 2"		
(2) Grind, file or sandpaper joint area. (Do not use a wire brush)		
Note: Do not use aluminum-oxide emery paper.		
b. Positioning		
(1) Alignment of joint (no gap) Hold vertical strip in place by the use of a steel strip or rod (touching top edge of vertical strip and bench top). Do not tack.		
c. Fluxing		
(1) Apply flux over entire joint area.		
d. Preheat		
(1) Preheat entire joint area.		
Note: Proper preheat is obtained if flux remains liquid when torch is removed from strips - Keep flame off of flux.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

e. Brazing

(1) Feed brazing alloy into joint until alloy no longer disappears from fillet. Complete penetration must be obtained.

Note: If alloy smokes, too much heat is being applied.

(2) Throat of fillet must not exceed 1/32"

f. Post heat

(1) Bring test strips to uniform temperature.

g. Cleaning

(1) Quench after test strips temperature drops below 700° F.

(2) Completely remove all flux by chipping and wire brushing.

Note: Protect hands and eyes when cleaning off flux - it will cut like glass.

3. Tee joint (vertical)

a. Preparation

(1) Sample strips 1/16" x 1" x 2"

(2) Grind, file or sandpaper joint area. (Do not use a wire brush)

Note: Do not use aluminum-oxide emery paper.

b. Positioning

(1) Alignment of joint (no gap). Hold strips in place by the use of fire bricks - Do not tack

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Fluxing		
(1) Apply flux over entire joint area.		
d. Preheat		
(1) Preheat entire joint area.		
Note: Proper preheat is obtained if flux remains liquid when torch is removed from strips. Keep flame off of flux.		
e. Brazing	7. Stress why alloy must be fed from top in a vertical joint.	
(1) Feed brazing alloy from top end of joint and permit capillary and gravity action to fill the joint down vertical. Feed the alloy until it no longer disappears from fillet.		
Note: If alloy smokes, too much heat is being applied.		
(2) Throat of fillet buildup must not exceed 1/32"		
f. Post heat		
(1) Bring test strips to uniform temperature		
g. Cleaning		
(1) Quench after test strips temperature drops below 700° F.		
(2) Completely remove all flux by chipping and wire brushing		
Note: Protect hands and eyes when cleaning off flux - it will cut like glass.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

4. Lap joint (flat)

   a. Preparation

      (1) Sample strips 1/16" x 1" x 2"

      (2) Grind, file or sandpaper joint area. (Do not use a wire brush)

      Note: Do not use aluminum-oxide emery paper.

   b. Positioning

      (1) Alignment of joint (no gap). Lap strips 1/4". Support top strip on its free end by a 1/16" scrap strip and hold down with a fire brick, (Do not tack)

   c. Fluxing

      (1) Apply flux over entire joint area, including between lap joint.

   d. Preheat

      (1) Preheat entire joint area.

      Note: Proper preheat is obtained if flux remains liquid when torch is removed from strips - Keep flame off of flux.

   e. Brazing

      (1) Feed brazing alloy into joint until alloy no longer disappears. Complete penetration must be obtained.

      Note: If alloy smokes, too much heat is being applied

      (2) Throat of fillet buildup must not exceed 1/32"

OUTLINE OF INSTRUCTION

f. Post heat

(1) Bring test strips to uniform temperature

g. Cleaning

(1) Quench after test strips temperature drops below 700° F.

(2) Completely remove all flux by chipping and wire brushing

Note: Protect hands and eyes when cleaning off flux - It will cut like glass.

5. Lap joint (vertical)

a. Preparation

(1) Sample strips 1/16" x 1" x 2"

(2) Grind, file or sandpaper joint area. (Do not use wire brush)

Note: Do not use aluminum-oxide emery paper.

b. Positioning

(1) Alignment of joint (no gap). Hold strips in place by the use of fire bricks. Lap strips 1/4". (Do not tack).

c. Fluxing

(1) Apply flux over entire joint area, including between lap joints.

d. Preheat

(1) Preheat entire joint area

INSTRUCTOR ACTIVITY

8. Explain why a wire brush, and aluminum oxide paper should not not be used.

STUDENT ACTIVITY 1/2

OUTLINE OF INSTRUCTION

Note: Proper preheat is obtained if flux remains liquid when torch is removed - Keep flame off of flux.

e. Brazing

(1) Feed brazing alloy from top end of joint and permit capillary and gravity action to fill the joint down vertical. Feed the alloy until it no longer disappears from fillet.

Note: If alloy smokes, too much heat is being applied

(2) Throat of fillet buildup must not exceed 1/32"

f. Post heat

(1) Bring test strips to uniform temperature

(2) Completely remove all flux by chipping and wire brushing.

Note: Protect hands and eyes when cleaning off flux - It will cut like glass

Insure that there is proper ventilation for the flux and metallic fumes and that the student does not position his face directly over the work.

Note: Silver brazing alloy is thinflowing and only the joint tolerance of .0015 to .003 should be filled with little or no buildup

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

III. APPLICATION:

A. Questions and Discussion

1. Is silver alloy thin-flowing or bead-forming

ANS: Thin-flowing

2. How can a lap joint be set up to retain close-joint tolerance during brazing?

ANS: Support the free end of the top strip with a piece of scrap metal equal to the thickness of the bottom strip.

3. Immediately after brazing, what should be done to the test strips?

ANS: Post heat uniformily

4. Why should the joint be completely fluxed prior to brazing?

ANS: Unfluxed areas will oxidize.

IV. SUMMARY:

A. Silver Brazing (brass) 1/16" x 1" x 2"

1. Square butt (flat)

   a. Preparation

   b. Positioning

   c. Fluxing

   d. Preheat

   e. Brazing

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
f. Post heat		
g. Cleaning		
2. Tee joint (flat)		
a. Preparation		
b. Positioning		
c. Fluxing		
d. Preheat		
e. Brazing		
f. Post heat		
g. Cleaning		
3. Tee joint (vertical)		
a. Preparation		
b. Positioning		
c. Fluxing		
d. Preheat		
e. Brazing		
f. Post heat		
g. Cleaning		
4. Lap joint (vertical)		
a. Preparation		
b. Positioning		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Fluxing		
d. Preheat		3. Practice silver brazing brass joints.
e. Brazing		
f. Post heat		
g. Cleaning		
V. TEST;		4. Practical Test
A. Practical Test (Silver Brazing Brass)		a. Butt joint (flat)
1. Butt joint (flat)		b. Tee joint (flat)
2. Tee joint (flat)		c. Tee joint (vertical
3. Tee joint (vertical)		d. Lap joint (flat)
4. Lap joint (flat)		e. Lap joint (vertical
5. Lap joint (vertical)		
B. Written Test		
1. Annealing, hardening and tempering		
2. Welding equipment applications		
3. Correct welding rod selection		
VI. ASSIGNMENT		
A. "The Welding Encyclopedia", 16th edition, Pages C-32, P-40 and P-41.		

NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043
STEELWORKER STT SCHOOL TRAINING COURSE 615-2

Classification: **Unclassified**

Topic: **Silver Brazing Stainless**

Average Time: **Pract: 4 periods**

Instructional Materials:

A. **Training Aids: None**

B. **Publications**

1. **Text: None**
2. **Reference:**
    a. **"Brazing Manual" American Welding Society**

C. **Equipment and materials:**

1. **Major equipment**
    a. **Gas welding equipment**
2. **Tools:**
    a. **Gloves**
    b. **Goggles**
    c. **Pliers**
    d. **Slag hammer**

Terminal Objective: 3.1

Enabling Objective: Upon completion of this topic the student will be able to:

A. Silver braze a tee joint of Stainless Steel 1/16" x 1" x 2" with an oxy-gas torch in the flat and vertical position.

B. Silver braze a 1/4" lap joint of Stainless Steel 1/16" x 1" x 2" with an oxy-gas torch in the flat and vertical posiiton.

C. The above shall be done with a joint of .0015 to .003 and with no buildup.

Criterion Test:

The student will silver braze a tee joint of Stainless Steel 1/16" x 1" x 2" with an oxy-gas torch in the flat and vertical posiiton. Silver Braze a 1/4" lap joint of Stainless Steel 1/16" x 1" x 2" with an oxy-gas torch in the flat and vertical position. The above shall be done with a joint of .0015 to .003 and with no build up.

Homework: Reading assignment

1. **"The Welding Encyclopedia" 16th edition, pages M-16 - M-17**

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e. Spark lighter

f. Tip cleaners

g. Wire brush

3. Materials

a. Flux

b. Mapp gas

c. Oxygen

d. Silver brazing alloy (cadmium free) 1/16"

e. Stainless Steel strip 1/16" x 1"

D. Instructor Prepared Materials (Local)

None

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the Lesson	1. Introduce self and topic.	
A. Establish contact.		
1. Name:		
2. Topic:Silver Brazing Stainless		
B. Establish readiness	2. Motivate student.	
1. Purpose		
2. Assignment		
C. Establish effect	3. Bring out need and value of material being presented.	
1. Value		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better steelworker		
D. Overview: 1. Silver Brazing (Stainless)1/16" x 1" x 2" a. Tee joint (1) flat (2) Vertical b. Lap joint (1) flat (2) Vertical	4. State learning objectives. a. State information and materials necessary to guide student.	

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. PRESENTATION A. Silver Brazing (stainless) 1. Tee joint (flat) a. Prepartion (1) Sample strips 1/16" x 1" x 2" (2) Grind, file or sandpaper joint area. (Do not use a wire brush) Note: Do not use aluminum-oxide emery paper.	5. Draw on the chalkboard diagrams of the tee and lap joints and the method of applying and drawing the alloy through the joints.	1. Take notes
b. Positioning (1) Alignment of joint (no gap). Hold vertical strip in place by the use of a steel strip or rod (touching top edge of vertical strip and bench top) - Do no tack. c. Fluxing (1) Apply flux over entire joint area d. Preheat (1) Preheat entire joint area. Note: Proper preheat is obtained if flux remains liquid when torch is removed from strips - keep flame off of flux	6. Insure the students understand the importance of perfect alignment.	2. Ask question when in doubt

OUTLINE OF INSTRUCTION

e. Brazing

(1) Feed brazing alloy into joint until alloy no longer disappears from fillet. Complete penetration must be obtained.

Note: If alloy smokes, too much heat is being applied.

(2) Throat of fillet buildup must not exceed 1/32"

f. Post heat

(1) Bring test strips to uniform temperature.

g. Cleaning

(1) Quench after test strips temperature drops below 700° F.

(2) Completely remove all flux by chipping and wire brushing.

Note: protect hands and eyes when cleaning off flux - it will cut like glass.

2. Tee joint (vertical)

a. Preparation

(1) Sample strips 1/16" x 1" x 2"

(2) Grind, file or sandpaper joint area. (Do not use a wire brush)

Note: Do not use aluminum-oxide emery paper.

b. Positioning

(1) Alignment of joint (no gap). Hold strips in place by the use of fire bricks - Do not tack

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

c. Fluxing

(1) Apply flux over entire joint area

d. Preheat

(1) Preheat entire joint area

Note: Proper preheat is obtained if flux remains liquid when torch is removed from strips - Keep flame off of flux.

e. Brazing

(1) Feed brazing alloy from top end of joint and permit capillary and gravity action to fill the joint down vertical. Feed the alloy until it no longer disappears from fillet

Note: If alloy smokes, too much heat is being applied.

(2) Throat of fillet buildup must not exceed 1/32 "

f. Post heat

(1) Bring test strips to uniform temperature.

g. Cleaning

(1) Quench after test strips temperature drops below 700° F.

(2) Completely remove all flux by chipping and wire brushing.

Note: Protect hands and eyes when cleaning off flux - it will cut like glass.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

3. Lap joint (flat)

   a. Preparation

      (1) Sample strips 1/16" x 1" x 2"

      (2) Grind, file or sandpaper joint area. (Do not use a wire brush)

      Note: Do not use aluminum-oxide emery paper.

   b. Positioning

      (1) Alignment of joint (no gap). Lap strips 1/4". Support top strip on its free end by a 1/16" scrap strip and hold down with a fire brick. (Do not tack)

   c. Fluxing

      (1) Apply flux over entire joint area, including between lap joint.

   d. Preheat

      (1) Preheat entire joint area.

      Note: Proper preheat is obtained if flux remains liquid when torch is removed from strips - keep flame off of flux.

   e. Brazing

      (1) Feed brazing alloy into joint until alloy no longer disappears. Complete penetration must be obtained

      Note: If alloy smokes, too much heat is being applied

      (2) Throat of fillet buildup must not exceed 1/32"

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
f. Post heat (1) Bring test strips to uniform temperature g. Cleaning (1) Quench after test strips temperature drops below 700° F. (2) Completely remove all flux by chipping and wire brushing, Note: Protect hands and eyes when cleaning off flux - it will cut like glass. 4. Lap joint (vertical) a. Preparation (1) Sample strips 1/16" x 1" x 2" (2) Grind, file or sandpaper joint area. (Do not use wire brush) Note: Do not use aluminum-oxide emery paper. b. Positioning (1) Alignment of joint (no gap). Hold strips in place by the use of fire bricks. Lap strips 1/4". (Do not tack) c. Fluxing (1) Apply flux over entire joint area, including between lap joint. d. Preheat (1) Preheat entire joint area		

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OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

Note: Proper preheat is obtained if flux remains liquid when torch is removed. Keep flame off of flux.

e. Brazing

(1) Feed brazing alloy from top end of joint and permit capillary and gravity action to fill the joint down vertical. Feed the alloy until it no longer disappears from fillet.

Note: If alloy smokes, too much heat is being applied

(2) Throat of fillet buildup must not exceed 1/32"

f. Post heat

(1) Bring test strips to uniform temperature

g. Cleaning

(1) Quench after test strips temperature drops below 700° F.

(2) Completely remove all flux by chipping and wire brushing.

Note: Protect hands and eyes when cleaning off flux - it will cut like glass.

Insure that there is proper ventilation for the flux and metallic fumes and that the student does not position his face directly over the work.

Silver brazing alloy is thinflowing and only the joint tolerance of .0015 to .003 should be filled with little or no build-up

OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

III. APPLICATION

A. Questions and Discussion

1. Where should silver alloy be fed in a vertical joint?

ANS:Top end of joint

2. What is the maximum throat dimensions on a fillet in a silver brazed joint?

ANS: 1/32"

3. How much should a lap joint be lapped?

ANS: 1/4"

4. Which one of the silver-brazed test strips should be tacked prior to brazing?

ANS: None

IV. SUMMARY:

A. Silver Brazing (Stainless) 1/16" x 1" x 2"

1. Tee joint (flat)

a. Preparation

b. Positioning

c. Fluxing

d. Preheat

e. Brazing

f. Post heat

g. Cleaning

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OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

2. Tee joint
    - a. Preparation
    - b. Positioning
    - c. Fluxing
    - d. Preheat
    - e. Brazing
    - f. Post heat
    - g. Cleaning

3. Lap joint(flat)
    - a. Preparation
    - b. Positioning
    - c. Fluxing
    - d. Preheat
    - e. Brazing
    - f. Post heat
    - g. Cleaning

4. Lap joint (vertical)
    - a. Preparation
    - g. Postioning
    - c. Fluxing
    - d. Preheat

OUTLINE OF INSTRUCTION

e. Brazing

f. Post heat

g. Cleaning

V. TEST

A. Practical Test (Silver Brazing Stainless)

1. Tee joint (flat)

2. Tee joint (vertical)

3. Lap joint (flat)

4. Lap joint (vertical)

VI ASSIGNMENT:

A. "The Welding Encyclopedia", 16th edition, Pages M-16 and M-17.

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

3. Practical Test
   a. Tee joint (flat)

   b. Tee joint (vertical

   c. Lap joint (flat)

   d. Lap joint (vertical

4. Reading assignment

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CHAPTER 1

BLUEPRINTS

Blueprints are reproduced copies of mechanical or other types of technical drawings. The term "blueprint reading" means interpreting the ideas expressed by others on drawings, whether the drawings are actually blueprints or not.

Drawing or sketching is the universal language used by engineers, technicians, and skilled craftsmen. Whether this drawing is made freehand or with drawing instruments, it is needed to convey all the necessary information to the individual who will fabricate and assemble the object whether it be a building, ship, aircraft, or a mechanical device. If many people are involved in the fabrication of the object, copies (prints) are made of the original drawing or tracing so that all persons involved will have the same information. Not only are drawings used as plans to fabricate and assemble objects, they are also used to illustrate how machines, ship, aircraft, etc., are operated, repaired, and maintained.

This chapter contains general information concerning blueprints. After studying this chapter you should be able to tell how blueprints are made and reproduced, what information is contained on a blueprint, and where this information is located. You will be able to state the meaning of the various types of lines used on blueprints and list the precautions to be observed when handling blueprints. You will also be able to define the common types of shipboard blueprints and describe how they are numbered and filed.

HOW PRINTS ARE MADE

A mechanical drawing is drawn with instruments such as compasses, ruling pens, T-squares, triangles, and french curves. Prints (copies) are reproduced from original drawings in much the same manner as photographic prints are reproduced from negatives.

The original drawings for prints are made by drawing directly on, or tracing a drawing on a translucent tracing paper or cloth, using black waterproof (india) ink or a drawing pencil. This original drawing is normally referred to as a tracing "master copy." These copies of the tracings are rarely, if ever, sent to a shop or job site. Instead, reproductions of these tracings are made and distributed to person or offices where needed. These tracings can be used over and over indefinitely if properly handled and stored.

From these tracings, mentioned in the previous papagraph, blueprints are made. The term blueprint is a rather loosely used term in dealing with reproductions of orignal drawings. One of the first processes devised to reproduce or duplicate tracings produced white lines on a blue background, hence the term blueprints. Today, however, other methods of reproduction have been developed, and they produce prints of different colors. The colors may be brown, black, gray, or maroon. The differences lie in the types of paper and the developing processes used.

A patented paper identified as "BW" paper produces prints with black lines on a white background.

The ammonia process or "OZALIDS" produces prints with either black, blue, or maroon lines on a white background.

Vandyke paper produces a white line on a dark brown background.

Other processes that may be used to reproduce drawings, usually small drawings or sketches, are the office type duplicating machines, such as the mimeograph, ditto machines, and the like. One other type of duplicating process rarely used for reproducing working drawings is the photostatic process. This in reality is a photographic process in which a large camera reduces or enlarges a tracing or drawing. The photostat has white lines on a dark background when reproduced directly from a tracing or

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drawing. If the photostated print is then reproduced, it will have brown lines on a white background. Photostats are generally used by various businesses for incorporating reduced size drawings into reports or records.

Military drawings and blueprints are prepared in accordance with the definitely prescribed standards and procedures set forth in Military Standards (MIL-STDS). These MIL-STDS are listed in the Department of Defense Index of Specifications and Standards, which is issued as of 31 July of each year. Common MIL-STDS concerning engineering drawings and blueprints are listed by number and title below.

NUMBER	TITLE
MIL-STD-100A	Engineering drawing practices
MIL-STD-8C	Dimensioning and tolerancing
MIL-STD-9A	Screw thread conventions and methods of specifying
MIL-STD-10A Change 2	Surface roughness, waviness, and lay
MIL-STD-12B	Abbreviations for use on drawings
MIL-STD-14A	Architectural symbols
MIL-STD-15 Part No. 1	Graphic symbols for electrical and electronics diagrams part 1A
MIL-STD-15 Part No. 2	Electrical wiring equipment symbols for ships plans part 2
MIL-STD-15 Part No. 3	Electrical wiring symbols for architectural and electrical layout drawings, part 3
MIL-STD-16C	Electrical and electronic reference designations
MIL-STD-17B Part 1	Mechanical Symbols
MIL-STD-17B Part No. 2 Change 1	Mechanical symbols for aeronautical, aerospacecraft, and spacecraft use
MIL-STD-18A	Structural symbols
MIL-STD-20	Welding terms and definitions
MIL-STD-21	Welded-joint designs, armored-tank type
MIL-STD-22A	Welded joint design
MIL-STD-25 Change 1	Nomenclature and symbols for ship structure

PARTS OF A BLUEPRINT

Military blueprints are prepared as to size, format, location of, and information included, in the various blocks, etc. according to MIL-STD-100A of 1 October 1967. The various parts of a blueprint are described briefly in the following paragraphs.

TITLE BLOCK

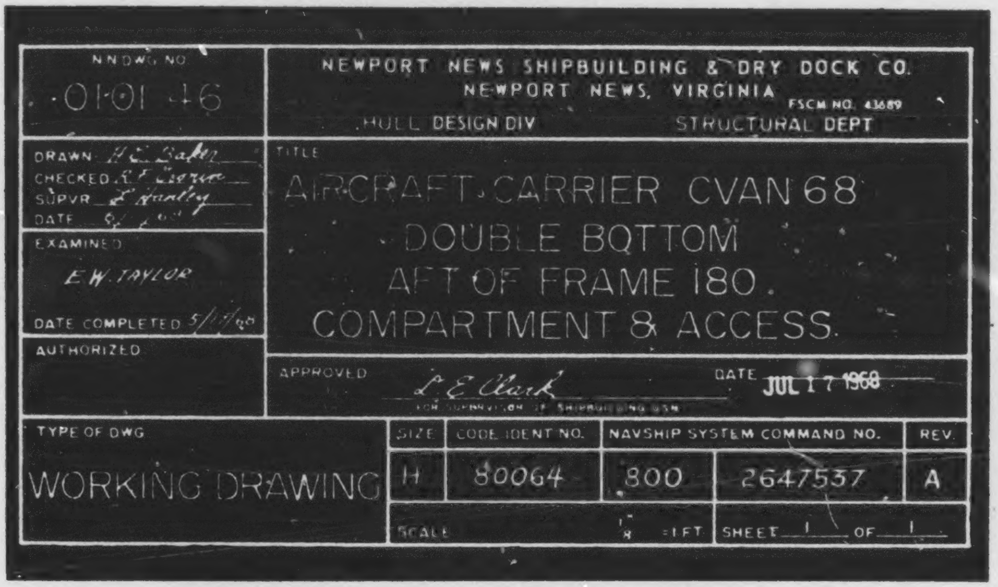
The title block is located in the lower right-hand corner of all blueprints and drawings prepared in accordance with Military Standards. The block contains the drawing number, the name of the part or assembly that the blueprint represents, and all information required to identify the part or assembly.

The title block also includes the name and address of the Government agency or organization preparing the drawing, the scale, drafting record, authentication, and the date (fig. 1-1).

A space within the title block with a diagonal or slant line drawn across it (not shown in fig. 1-1) indicates that the information usually placed in it is not required or is given elsewhere on the drawing.

REVISION BLOCK

The revision block (not shown) is usually located in the upper right-hand corner of the blueprint and is used for the recording of changes (revisions) to the print. All revisions are noted in this block and are dated and identified by a letter, and a brief description of the revision. A revised drawing is shown by the addition of a letter to the original number as shown in figure



N.N.DWG. NO.
01-01-46

NEWPORT NEWS SHIPBUILDING & DRY DOCK CO.
NEWPORT NEWS, VIRGINIA
FSCM NO. 43689
HULL DESIGN DIV
STRUCTURAL DEPT

DRAWN H.E. Baker
CHECKED R.F. Carver
SUPVR E. Hanley
DATE [illegible]

TITLE
AIRCRAFT CARRIER CVAN 68
DOUBLE BOTTOM
AFT OF FRAME 180
COMPARTMENT & ACCESS

EXAMINED
E.W. TAYLOR

DATE COMPLETED 5/17/68

AUTHORIZED

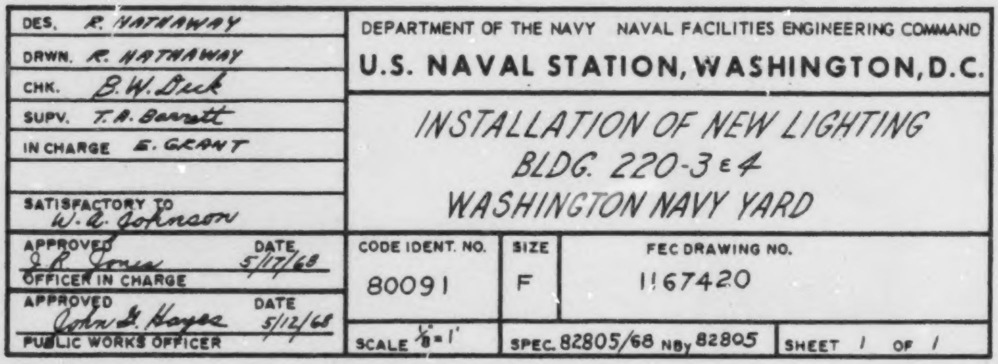
APPROVED L.E. Clark
FOR SUPERVISOR OF SHIPBUILDING USN
DATE JUL 17 1968

TYPE OF DWG
WORKING DRAWING

SIZE	CODE IDENT NO.	NAVSHIP SYSTEM COMMAND NO.		REV.
H	80064	800	2647537	A

SCALE 1/8" = 1 FT
SHEET 1 OF 1

A



DES. R. HATHAWAY
DRWN. R. HATHAWAY
CHK. B.W. Buck
SUPV. T.A. Barrett
IN CHARGE E. GRANT

SATISFACTORY TO
W. A. Johnson

APPROVED J.R. Jones DATE 5/17/68
OFFICER IN CHARGE

APPROVED John D. Hayes DATE 5/12/68
PUBLIC WORKS OFFICER

DEPARTMENT OF THE NAVY NAVAL FACILITIES ENGINEERING COMMAND
U.S. NAVAL STATION, WASHINGTON, D.C.

INSTALLATION OF NEW LIGHTING
BLDG. 220-3 & 4
WASHINGTON NAVY YARD

CODE IDENT. NO.	SIZE	FEC DRAWING NO.
80091	F	1167420

SCALE 1/8" = 1'
SPEC. 82805/68 NBy 82805
SHEET 1 OF 1

B

45.159(65)

Figure 1-1.—Blueprint title blocks. (A) Naval Ship Systems Command; (B) Naval Facilities Engineering Command.

1-1A. If the print shown in figure 1-1A was again revised, the letter A in the revision block would be replaced by the letter B.

DRAWING NUMBER

All blueprints are identified by a drawing number, (NavShip Systems Command No. fig. 1-1A, and FEC drawing No. fig. 1-1B), which appears in a block in the lower right corner of the title block. It may be shown in other places also; for example, near the top border line in the upper corner, or on the reverse side at both ends so that it will be visible when a drawing is rolled up. (Numbering shipboard blueprints is discussed later in this chapter.)

If a blueprint has more than one sheet, this information is included in the number block indicating the sheet number and the number of sheets in the series. For example, note that in the title blocks shown in figure 1-1, the sheet is sheet 1 of 1.

REFERENCE NUMBERS

Reference numbers that appear in the title block refer to numbers of other blueprints. When more than one detail is shown on a drawing, a dash and a number are frequently used. For example, if two parts are shown in one detail drawing, both prints would have the same drawing number, plus a dash and an individual number, such as, 8117041-1 and 8117041-2.

In addition to appearing in the title block, the dash and number may appear on the face of the drawings near the parts they identify. Some commercial prints show the drawing and dash number and point with a leader line to the part; others use a circle, 3/8 inch in diameter around the dash number, and carry a leader line to the part.

A dash and number are used to identify modified or improved parts, and also to identify right-hand and left-hand parts. Many aircraft parts on the left-hand side of an aircraft are exactly like the corresponding parts on the right-hand side—in reverse. The left-hand part is usually shown in the drawing.

Above the title block on some prints you may see a notation such as "159674 LH shown; 159674-1 RH opposite." Both parts carry the same number. But the part called for is distinguished by a dash and number. (LH means left-hand, and RH means right-hand.) Some companies use odd numbers for right-hand parts and even numbers for left-hand parts.

ZONE NUMBERS

Zone numbers on blueprints serve the same purpose as the numbers and letters printed on borders of maps to help you locate a particular point. To find a particular point, you mentally draw horizontal and vertical lines from these letters and numerals, and the point where these lines intersect is the particular point sought.

You will use practically the same system to help you locate parts, sections, and views on large blueprinted objects (for example, assembly drawings of aircraft). Parts numbered in the title block can be located on the drawing by looking up the numbers in squares along the lower border. Zone numbers read from right to left.

SCALE

The scale of the blueprint is indicated in one of the spaces within the title block. It indicates the size of the drawing as compared with the actual size of the part. The scale may be shown as 1" = 2", 1" = 12", 1/2" = 1', and so on. It may also be indicated as full size, one-half size, one-fourth size, and so on.

If a blueprint indicates that the scale is 1" = 2", each line on the print is shown one-half its actual length. A scale showing 3" = 1" each line on the print is three times its actual length.

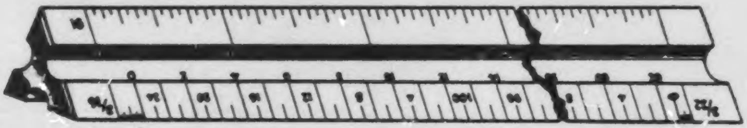
Very small parts are enlarged to show the views clearly, and large objects are normally reduced in size to fit on a standard size drawing paper. In short, the scale is selected to fit the object being drawn and space available on a sheet of drawing paper.

Remember: NEVER MEASURE A DRAWING. USE DIMENSIONS. Why? Because the print may have been reduced in size from the original drawing; Or, you might not take the scale of the drawing into consideration. Then, too paper stretches and shrinks as the humidity changes, thus introducing perhaps, the greatest source of error in actually taking a measurement by laying a rule on the print itself. Play it safe and READ the dimensions on the drawing; they always remain the same.

Graphical scales are often placed on maps and plot plans. These scales indicate the number of feet or miles represented by an inch. A fraction is often used, as 1/500, meaning that one unit on the map is equal to 500 like units on the ground. A LARGE-SCALE MAP has a scale of 1" = 10'; a map with a scale of 1" = 1000' is considered to be a SMALL-SCALE MAP.

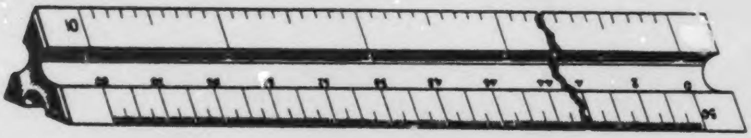
Various types and shapes of scales are used in preparing blueprints. Three common types are shown in figure 1-2.

Architects' scales (fig.1-2A), are divided into proportional feet and inches and are generally used in scaling drawings for machine and structural work. The triangular architects' scale usually contains 11 scales, each subdivided differently. Six scales read from the left end, while five scales read from the right end.



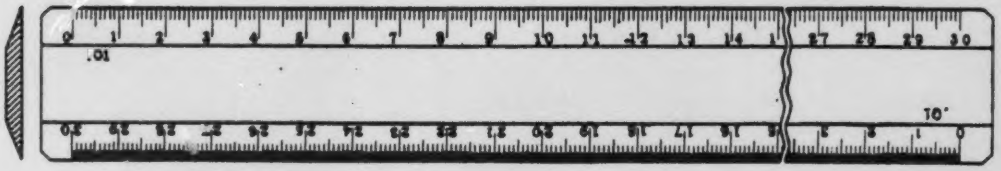
Ⓐ

ARCHITECTS' SCALE



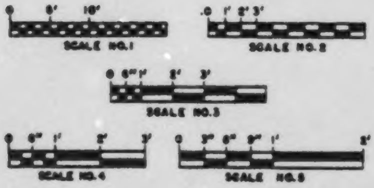
Ⓑ

ENGINEERS' SCALE


0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 27 28 29 30
.01
10"

Ⓒ

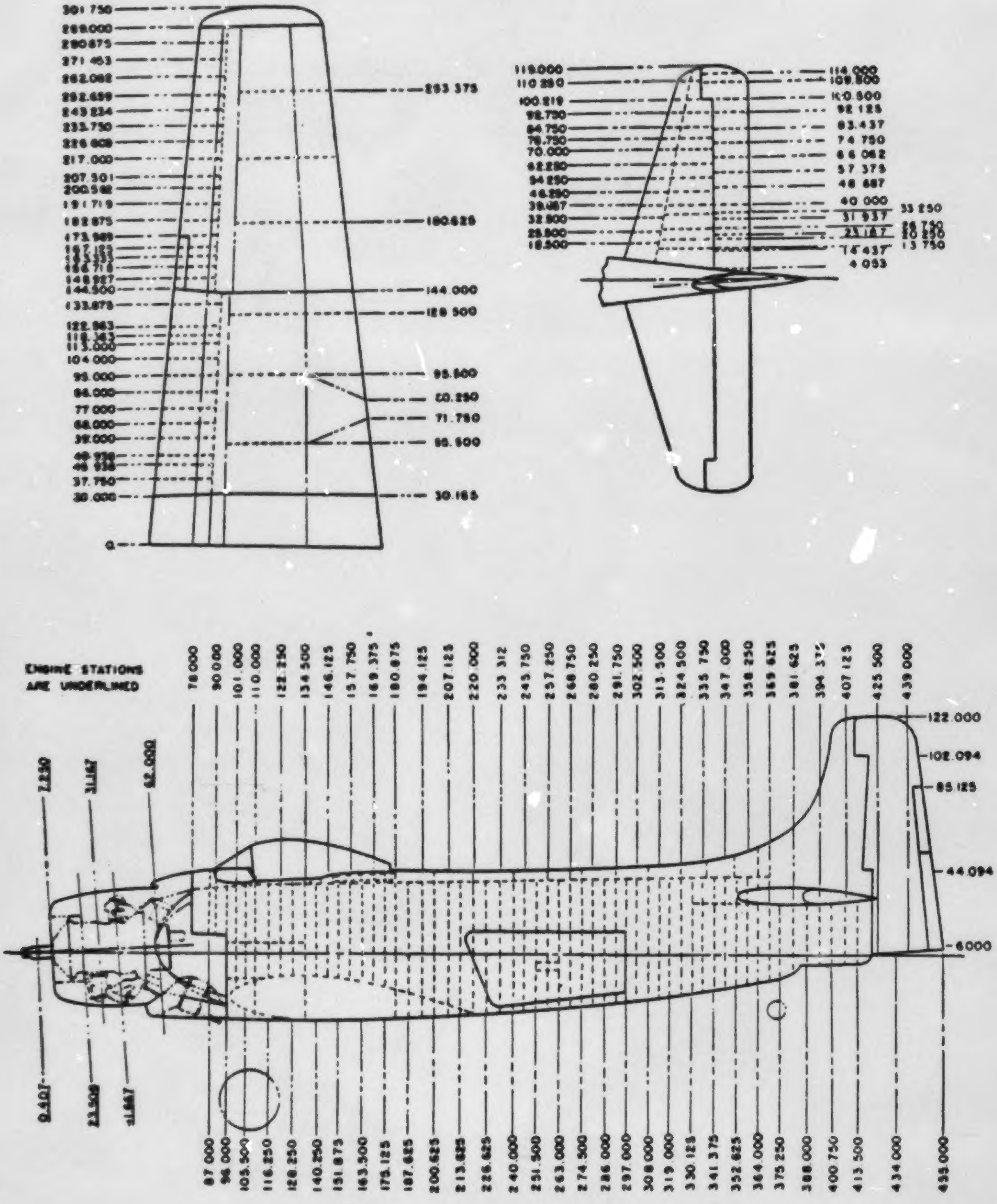
METRIC SCALE


0 5' 10'
SCALE NO.1
0 1' 2' 3'
SCALE NO.2
0 6" 1' 2' 3'
SCALE NO.3
0 6" 1' 2' 3'
SCALE NO.4
0 3" 6" 9" 1' 2'
SCALE NO.5

Ⓓ

GRAPHIC SCALES

4.16(65)A
Figure 1-2. — Types of scales.


301.750
289.000
280.875
271.453
262.082
252.659
243.234
233.750
226.608
217.000
207.501
200.582
191.719
182.875
173.989
144.500
133.875
122.963
118.163
113.000
104.000
95.000
86.000
77.000
68.000
59.000
37.750
30.000
0
253.375
180.625
144.000
128.500
95.500
80.250
71.750
55.500
30.165
119.000
110.250
100.219
92.750
84.750
78.750
70.000
62.250
54.250
46.250
39.487
32.500
25.500
18.500
114.000
109.500
100.500
92.125
83.437
74.750
66.062
57.375
48.687
40.000
31.937
23.187
14.437
4.053
33.250
26.750
20.250
13.750
ENGINE STATIONS ARE UNDERLINED
78.000
90.000
101.000
110.000
122.250
134.500
146.125
157.750
169.375
180.875
194.125
207.125
220.000
233.312
245.750
257.250
268.750
280.250
291.750
302.500
313.500
324.500
335.750
347.000
358.250
369.625
381.625
394.375
407.125
425.500
439.000
122.000
102.094
85.125
44.094
6.000
7.250
31.167
62.000
9.407
23.505
31.667
87.000
96.000
105.500
116.250
128.250
140.250
151.875
163.500
175.125
187.625
200.625
213.625
226.625
240.000
251.500
263.000
274.500
286.000
297.000
308.000
319.000
330.125
341.375
352.625
364.000
375.250
388.000
400.750
413.500
434.000
455.000

65.9

Figure 1-3.—Aircraft stations and frames.

Figure 1-2A shows how the 3/16-inch subdivision of the architects' scale is further subdivided into 12 equal parts representing 1 inch each, and the 3/32-inch subdivision into 6 equal parts representing 2 inches each.

Engineers' scales (fig. 1-2B), are divided into decimal graduations (10, 20, 30, 40, 50, and 60 divisions to the inch). These scales are used for plotting and map drawing and in the graphic solution of problems.

Metric scales (fig. 1-2C), are used in conjuntion with drawings, maps, and so forth, made in countries using the metric system. This system is also being used with increasing frequency in the United States. The scale is divided into centimeters and millimeters. In conversion, 2.54 cm (centimeters) are equal to 1 inch.

Graphic Scales (fig. 1-2D), are lines subdivided into distances corresponding to convenient units of length on the ground or of the object represented by the blueprint. They are placed in or near the title block of the drawing and their relative lengths to the scales of the drawing are not affected if the print is reduced or enlarged.

STATION NUMBERS

Various systems of station marking are used on aircraft drawings. For example, the center line of the airplane on one drawing may be taken as the zero station, and objects to the right or left of center along the wings or stabilizers may then be located by giving the number of inches between them and the center line zero station. On other drawings, the zero station may be at the nose of the fuselage, at a firewall, at the leading edge of a wing, or at some other location depending on the purpose of the drawing. Station numbers for a typical aircraft are shown in figure 1-3.

BILL OF MATERIAL

The bill of material block on a blueprint contains a list of the parts and/or material used on or required by the print concerned. The block identifies parts and materials by stock number or other appropriate number, and also lists the quantity used or required.

The bill of material often contains a list of standard parts, known as a parts list or schedule. Many commonly used items, such as machine bolts, screws, turnbuckles, rivets, pipefittings and valves have been standardized by the military. A bill of material for an electrical plan is shown in figure 1-4

APPLICATION BLOCK

The application block (fig. 1-5) is usually located near the title block and identifies directly or by reference the larger units of which the detail part of assembly on the drawing forms a component. The "next assembly" column (fig. 1-5), shows the drawing number or model number of the next larger assembly to which the drawing applies. The "used on" column shows the model number or equivalent designation of the assembled unit(s) of which the part is a component.

FINISH MARKS

Finish marks (√) are used on machine drawings to indicate surfaces that must be finished by machining. Machining provides a better surface appearance and provides the fit with closely mated parts. In manufacturing, during the finishing process the required limits and tolerances must be observed. MACHINED FINISHES should not be confused with finishes of paint, enamel, grease, chromium plating, and similar coating. Finish marks are discussed further in chapter 6 of this training course.

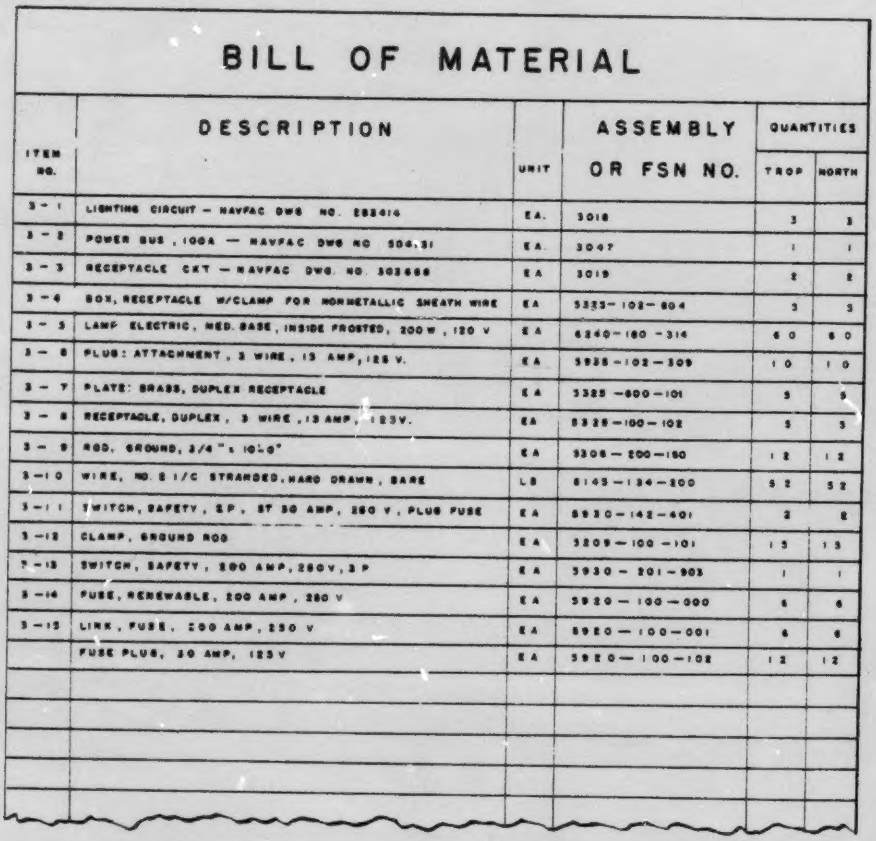
NOTES AND SPECIFICATIONS

Blueprints contain all the information about an object or part which can be presented graphically (that is, in drawing). A considerable amount of information can be presented this way, but there is more information required by supervisors, contractors, manufacturers, and craftsmen, which is not adaptable to the graphic form of presentation. Information of this type is generally given on the drawings as notes or as a set of specifications attached to be drawings.

NOTES are generally placed on drawings to give additional information to clarify the object on the blueprint. Leader lines are used to indicate the precise part being notated.

A SPECIFICATION is a statement or document containing a description or enumeration of particulars, as the terms of a contract, or details of an object or objects not shown on a blueprint or drawing.

Specifications (specs) describe items so that they may be procured, assembled, and maintained to function in accordance with the per-

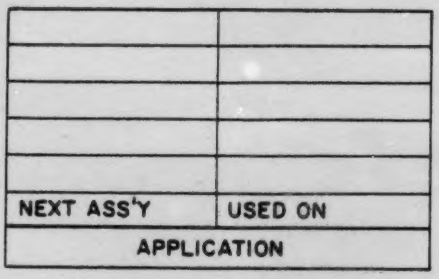


BILL OF MATERIAL

ITEM NO.	DESCRIPTION	UNIT	ASSEMBLY OR FSN NO.	QUANTITIES	
				TROP	NORTH
3-1	LIGHTING CIRCUIT — NAVFAC DWG NO. 283414	EA.	3018	3	3
3-2	POWER BUS, 100A — NAVFAC DWG NO 304,31	EA.	3047	1	1
3-3	RECEPTACLE CKT — NAVFAC DWG. NO. 303668	EA	3019	2	2
3-4	BOX, RECEPTACLE W/CLAMP FOR NONMETALLIC SHEATH WIRE	EA	5325-102-804	3	3
3-5	LAMP ELECTRIC, MED. BASE, INSIDE FROSTED, 200 W, 120 V	EA	6240-180-314	60	60
3-6	PLUG: ATTACHMENT, 3 WIRE, 15 AMP, 125 V.	EA	5935-102-309	10	10
3-7	PLATE: BRASS, DUPLEX RECEPTACLE	EA	5325-600-101	5	5
3-8	RECEPTACLE, DUPLEX, 3 WIRE, 15 AMP, 125V.	EA	5325-100-102	5	5
3-9	ROD, GROUND, 3/4" x 10'-0"	EA	5306-200-150	12	12
3-10	WIRE, NO. 2 1/C STRANDED, HARD DRAWN, BARE	LB	6145-134-200	52	52
3-11	SWITCH, SAFETY, 2P, ST 30 AMP, 250 V, PLUG FUSE	EA	5930-142-401	2	2
3-12	CLAMP, GROUND ROD	EA	5209-100-101	15	15
3-13	SWITCH, SAFETY, 200 AMP, 250V, 3P	EA	5930-201-903	1	1
3-14	FUSE, RENEWABLE, 200 AMP, 250 V	EA	5920-100-000	6	6
3-15	LINK, FUSE, 200 AMP, 250 V	EA	5920-100-001	6	6
	FUSE PLUG, 30 AMP, 125 V	EA	5920-100-102	12	12

65.10
Figure 1-4.—Bill of material.

formance requirements; furnish sufficient information to permit determination of conformance to the description; and furnish the above in sufficient completeness for accomplishment without the need of research, development, design engineering, or help from the preparing organization.



NEXT ASS'Y	USED ON
APPLICATION	

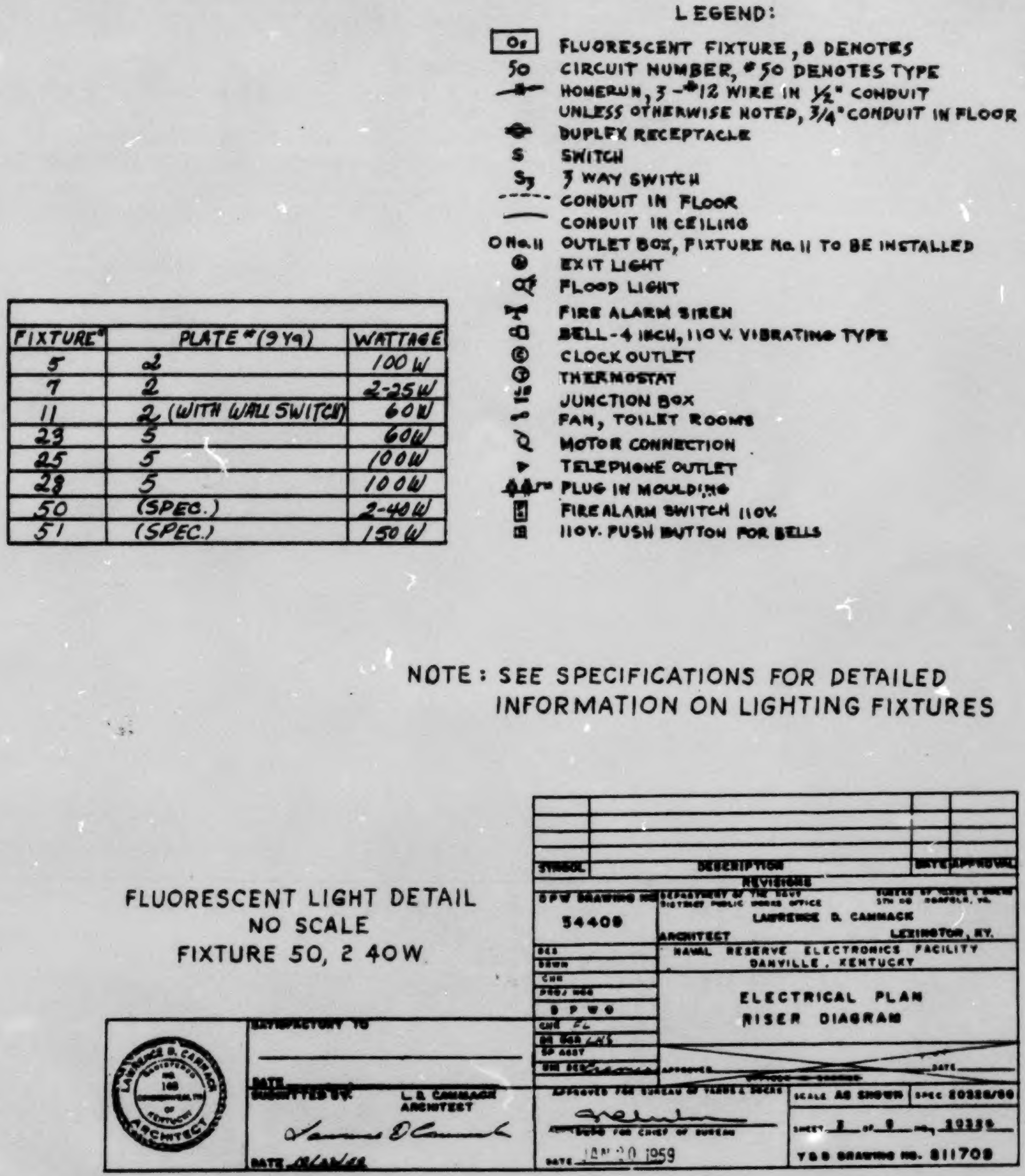
65.11
Figure 1-5.—Application block.

Federal specifications cover the characteristics of material and supplies used jointly by the Navy and other Government departments.

All Federal specifications used by the Navy Department as purchase specifications are listed in the Department of Defense Index of Specifications and Standards.

LEGEND OR SYMBOLS

The legend, if used, is generally placed in the upper right-hand corner of a blueprint below the revision block. The legend is used to explain or define a symbol or special mark placed on a blueprint. Figure 1-6 shows a legend for an electrical plan.



LEGEND:

O8	FLUORESCENT FIXTURE, 8 DENOTES
50	CIRCUIT NUMBER, #50 DENOTES TYPE
—#—	HOMERUN, 3-#12 WIRE IN ½" CONDUIT UNLESS OTHERWISE NOTED, 3/4" CONDUIT IN FLOOR
⊖	DUPLEX RECEPTACLE
S	SWITCH
S_3	3 WAY SWITCH
------	CONDUIT IN FLOOR
——	CONDUIT IN CEILING
O No. 11	OUTLET BOX, FIXTURE No. 11 TO BE INSTALLED
●	EXIT LIGHT
⊲	FLOOD LIGHT
⊤	FIRE ALARM SIREN
⊡	BELL-4 INCH, 110 V. VIBRATING TYPE
ⓒ	CLOCK OUTLET
ⓣ	THERMOSTAT
ⓙ	JUNCTION BOX
ⓕ	FAN, TOILET ROOMS
②	MOTOR CONNECTION
▶	TELEPHONE OUTLET
▲▲	PLUG IN MOULDING
▣	FIRE ALARM SWITCH 110V.
⊟	110V. PUSH BUTTON FOR BELLS

FIXTURE#	PLATE #(9Y9)	WATTAGE
5	2	100 W
7	2	2-25 W
11	2 (WITH WALL SWITCH)	60 W
23	5	60 W
25	5	100 W
28	5	100 W
50	(SPEC.)	2-40 W
51	(SPEC.)	150 W

NOTE: SEE SPECIFICATIONS FOR DETAILED INFORMATION ON LIGHTING FIXTURES

FLUORESCENT LIGHT DETAIL
NO SCALE
FIXTURE 50, 2 40W

SYMBOL DESCRIPTION DATE APPROVAL
REVISIONS

DPW DRAWING NO.
54409

DEPARTMENT OF THE NAVY
DISTRICT PUBLIC WORKS OFFICE
LAWRENCE D. CAMMACK
ARCHITECT LEXINGTON, KY.
NAVAL RESERVE ELECTRONICS FACILITY
DANVILLE, KENTUCKY

ELECTRICAL PLAN
RISER DIAGRAM

DES
DRWN
CHK
PROJ NGR
D P W O
CHK FL
DD [illegible]
SP ASST

SATISFACTORY TO
DATE
SUBMITTED BY: L. D. CAMMACK
ARCHITECT
DATE [illegible]

APPROVED FOR BUREAU OF YARDS & DOCKS
FOR CHIEF OF BUREAU
DATE JAN 20 1959

SCALE AS SHOWN
SPEC 20336/58
SHEET 2 OF 9
Y&D DRAWING NO. 811709

26.6
Figure 1-6.—An electrical plan.

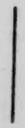
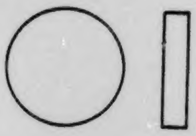
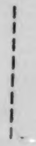
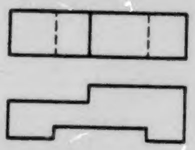
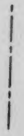
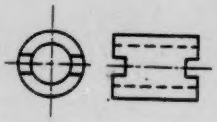
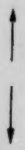
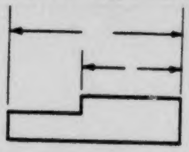
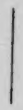
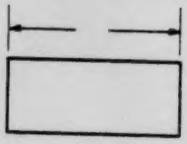
MEANING OF LINES

In order to be able to read blueprints you must acquire a knowledge of the use of lines. The alphabet of lines is the common language of the technician and the engineer.

In drawing an object, a draftsman not only arranges the different views in a certain manner, but he also uses different types of lines to convey information. Line characteristics such as width, breaks in the line, and zigzags have meaning, as shown by figure 1-7. Figure 1-8 shows the use of standard lines in a simple drawing.

SHIPBOARD BLUEPRINTS

Various types of blueprints (usually referred to as plans), are used in the construction, operation and maintenance of Navy ships. The common types are defined below.

LINE STANDARDS			
NAME	CONVENTION	DESCRIPTION AND APPLICATION	EXAMPLE
VISIBLE LINES		HEAVY UNBROKEN LINES USED TO INDICATE VISIBLE EDGES OF AN OBJECT	
HIDDEN LINES		MEDIUM LINES WITH SHORT EVENLY SPACED DASHES USED TO INDICATE CONCEALED EDGES	
CENTER LINES		THIN LINES MADE UP OF LONG AND SHORT DASHES ALTERNATELY SPACED AND CONSISTENT IN LENGTH USED TO INDICATE SYMMETRY ABOUT AN AXIS AND LOCATION OF CENTERS	
DIMENSION LINES		THIN LINES TERMINATED WITH ARROW HEADS AT EACH END USED TO INDICATE DISTANCE MEASURED	
EXTENSION LINES		THIN UNBROKEN LINES USED TO INDICATE EXTENT OF DIMENSIONS	

142.46

Figure 1-7.—Line characteristics and conventions for MIL-STD drawings.

PRELIMINARY plans are plans submitted with bids, or other plans, submitted prior to award of contract.

CONTRACT plans are plans which illustrate design features of the ship that are mandatory requirements.

CONTRACT GUIDANCE plans are plans which illustrate design features of the ship subject to development.

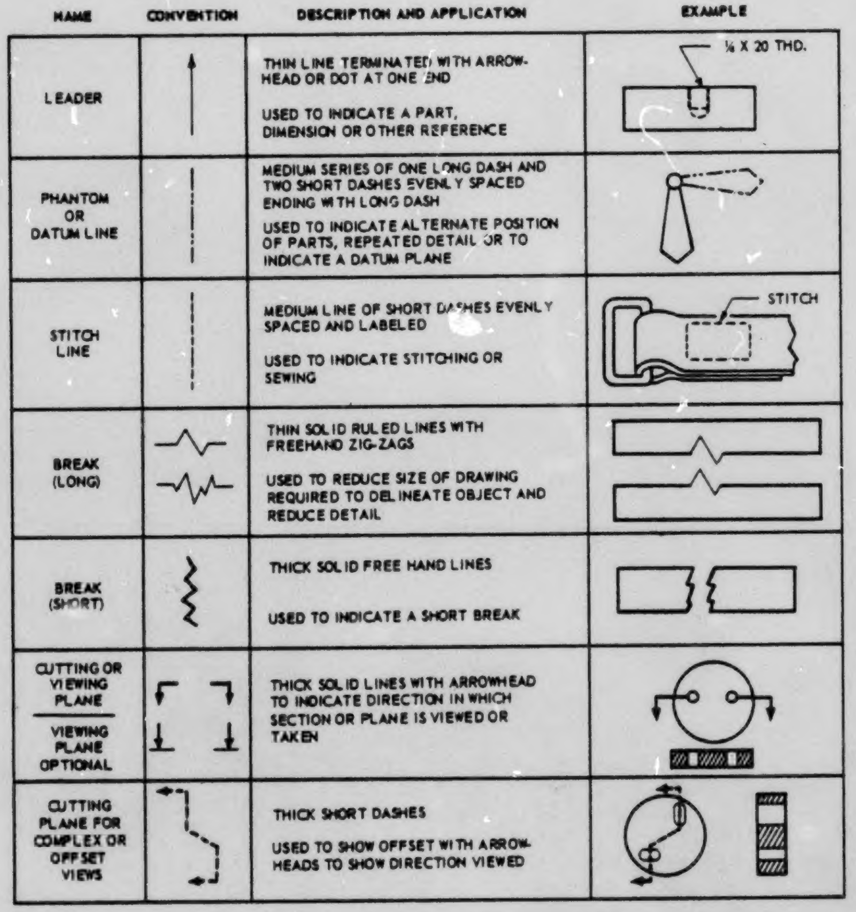
STANDARD plans are plans illustrating arrangement or details of equipment, system, or components for which specific requirements are mandatory.

TYPE plans are plans illustrating general arrangement of equipment, systems, or components which are not necessarily subject to strict compliance as to details provided the required results are accomplished.

WORKING plans are the contractor's construction plans which are necessary for construction of the ship.

CORRECTED plans are working plans which have been corrected to illustrate the final ship and system arrangement, fabrication, and installation.

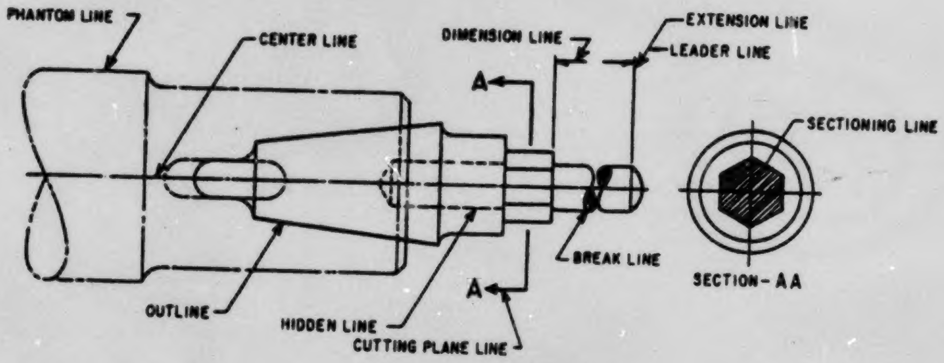
ONBOARD plans (discussed below) are a designated group of plans illustrating those features considered necessary for shipboard reference.



NAME	CONVENTION	DESCRIPTION AND APPLICATION	EXAMPLE
LEADER		THIN LINE TERMINATED WITH ARROWHEAD OR DOT AT ONE END USED TO INDICATE A PART, DIMENSION OR OTHER REFERENCE	¼ X 20 THD.
PHANTOM OR DATUM LINE		MEDIUM SERIES OF ONE LONG DASH AND TWO SHORT DASHES EVENLY SPACED ENDING WITH LONG DASH USED TO INDICATE ALTERNATE POSITION OF PARTS, REPEATED DETAIL OR TO INDICATE A DATUM PLANE	
STITCH LINE		MEDIUM LINE OF SHORT DASHES EVENLY SPACED AND LABELED USED TO INDICATE STITCHING OR SEWING	STITCH
BREAK (LONG)		THIN SOLID RULED LINES WITH FREEHAND ZIG-ZAGS USED TO REDUCE SIZE OF DRAWING REQUIRED TO DELINEATE OBJECT AND REDUCE DETAIL	
BREAK (SHORT)		THICK SOLID FREE HAND LINES USED TO INDICATE A SHORT BREAK	
CUTTING OR VIEWING PLANE VIEWING PLANE OPTIONAL		THICK SOLID LINES WITH ARROWHEAD TO INDICATE DIRECTION IN WHICH SECTION OR PLANE IS VIEWED OR TAKEN	
CUTTING PLANE FOR COMPLEX OR OFFSET VIEWS		THICK SHORT DASHES USED TO SHOW OFFSET WITH ARROWHEADS TO SHOW DIRECTION VIEWED	

142.46

Figure 1-7—Line characteristics and conventions for MIL-STD drawings—Continued.



45.150(65)
Figure 1-8.—Use of standard lines.

ONBOARD PLANS

Upon completion of a Navy ship, the shipbuilder furnishes the ship with copies of all plans considered necessary for operating and maintaining the ship(onboard plans), and a Ship Plan Index (SPI). The SPI lists all plans applicable to the ship concerned except plans for certain miscellaneous items covered by standard or type plans.

Onboard plans include only those plans considered by NavShips or the Supervisor of Shipbuilding as being necessary for shipboard reference. The SPI therefore should not be used as a checkoff list for the sole purpose of obtaining a complete set of all plans. When experience indicates the need for plans other than those furnished as onboard plans, or additional copies of onboard plans, they may be obtained from the home yard of the ship concerned or the System Command concerned. A guide for the selection of onboard plans appears in chapter 9001 of the NavShips Technical Manual.

NUMBERING

Shipboard plans are numbered according to MIL-STD-100. The complete plan number consists of five parts; size, code identification number, the system command number (consisting of a three-digit group number, and a serial or file number), and revision letter as shown in figure 1-1A. The size letter (H in fig. 1-1A), indicates the size of the blueprint according to the table of format size in MIL-STD-100. Size letters run from A (for the smallest print) to K (for the largest print).

The code identification number is a federal supply code number which identifies the design activity. Code number 80064 (fig. 1-1A) identifies NavShips. (Code number 80091 (fig. 1-1B) identifies the Naval Facilities Engineering Command.) The three-digit group number is assigned from the NavShips Consolidated Index of Drawings, Materials, and Services Related to Construction and Conversion. NavShips 0902-002-2000. This number identifies the equipment or system (or in some cases the type of plan) concerned. The number 800 (fig. 1-1A) identifies the plan as a contract plan.

The serial or file number is assigned from a block of numbers provided by the Supervisor of Shipbuilding. The revision letter denotes the latest revision of the plan as stated previously.

DLG 16	303	H	1844928	A

A

DD 880	S3801	H	1257161	A

B

65.161
Figure 1-9.—Shipboard plan numbers.

Figure 1-9 shows shipboard plan numbering systems that were used previous to the system just described. In the first block (DLG 16 in fig. 1-9A) is the ship identification of the lowest numbered ship for which the plan is applicable. The three-digit group number is taken from NavShips 0902-002-2000, and identifies the plan as a lighting system plan. The letter H denotes the plan size as explained previously.

Figure 1-9B shows the numbering system that was used before the adoption of the three-digit group system. The system used "S" group numbers which identified the equipment or system concerned. The number S3801 (fig. 1-9B) identifies the plan as a ventilation system plan. Plans using this numbering system may be related to the appropriate chapter of the NavShips Technical Manual by replacing the S of the "S" group number with the 9 of the NavShips Technical Manual chapter number and dropping the last digit of the "S" group number. In figure 1-9B, for example, this would produce the number 9380. Chapter 9380 of the NavShips Technical Manual is titled "Ventilation and Heating."

FILING

On most ships, plans are filed in the engineering log room. Aboard tenders and repair ships, they may be filed in the technical library or the microfilm library. The plans are filed in cabinets in numerical sequence according to the three-digit or "S" group number and the file number. When a later revision of a plan is received, the plan with the previous revision is removed from the file and destroyed, and the current plan filed in its place.

HANDLING BLUEPRINTS

Blueprints or prints are valuable permanent records that can be used over and over again if necessary. However, if you are to keep these prints as permanent records, you must handle them with care. Here are a few simple rules to follow to preserve these prints:

1. Keep them out of strong sunlight — they will fade.
2. Don't allow them to become wet or smudged with oil or grease; these ingredients seldom dry out completely, thereby making the prints practically useless.
3. Don't make pencil or crayon notations on a print without proper authority. If you receive instructions to mark a print, use an appropriate colored pencil and make the markings a permament part of the print. Yellow is a good color to use on a print with a blue background (blueprint).
4. Keep prints stowed in their proper place so they can be readily located the next time you want to refer to them.

Most of the prints that you will handle will be received properly folded. Your main concern will be to refold them correctly. You may, however, have occasion to receive prints that have not been folded at all, or have been folded improperly.

The method of folding prints depends upon the type and size of the filing cabinet, and the location of the identifying marks on the prints. It is preferable to place identifying marks at the top of prints when filing them vertically (upright), and at the bottom right-hand corner, when filing them flat. In some cases construction prints are stored in rolls.

3-24 172

CHAPTER 5

SHEET METAL LAYOUT AND FABRICATION

Your duties will involve a variety of tasks requiring skill with layout tools and the application of basic layout techniques. This chapter will describe methods of measuring, marking, cutting, forming, and joining sheet metal. We will also discuss the use of various handtools and power tools required in these operations and safety precautions applicable to shop work.

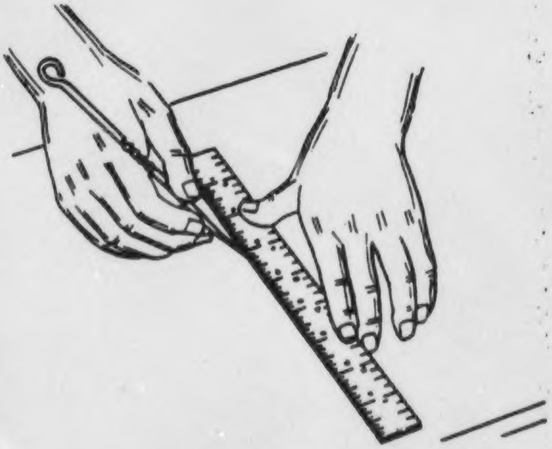
USING LAYOUT TOOLS

The LAYOUT of metal is essentially a process of measuring and marking material for cutting, drilling, or welding. Accuracy is very important in layout work, because it has an influence on the ease of subsequent fabrication, assembly, and joint operations. Using wrong measurements might easily result in a part being fabricated which doesn't fit in the overall job, thus wasting both time and material. In many instances, you will depend on blueprints and sketches as your guide to measurements for the fabrication job being laid out. Hence, ability to read and work from blueprints and sketches is important to your success in layout work. If you need basic information on blueprints, you will find chapters 1 and 8 of Blueprint Reading and Sketching, NavPers 10077-C, an excellent reference.

Layout tools, as the name implies, are used for laying out fabrication jobs on metal. Some of the more common layout tools which you may use in performing simple layout duties are as follows: flat steel square, combination square, protractor, prick punch, dividers, and trammel points.

Lines frequently are scribed with a SCRATCH AWL, using a STEEL SCALE or STRAIGHTEDGE. For best results in scribing, hold the scale or straightedge firmly in place, and set the point of the scriber as close to the edge of the scale as possible by tilting the scriber outward. Then exert pressure on the point and draw the line, tilting the tool slightly in the direction of movement. (See fig. 5-1.) For short lines, use the steel scale as a guide. For longer lines, use a circumference rule or a straightedge. When you have to draw a line between two points, prick punch each point. Start from one prick punch mark and scribe toward the center. Complete the line by scribing from the other prick punch mark in the opposite direction.

The FLAT STEEL SQUARE is a desirable tool for constructing perpendicular or parallel lines. In the method of layout known as parallel line development, the flat steel square is used to construct lines that are parallel to each other as well as perpendicular to the baseline. This procedure is illustrated in figure 5-2. Just clamp the straightedge firmly to the baseline. Slide the body of the square along the straightedge, and draw perpendicular lines through the desired points.



11.202X

Figure 5-1.—Scribing a line.

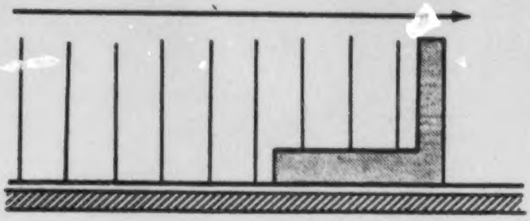
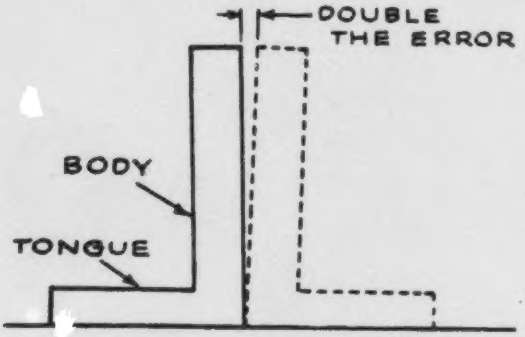


Figure 5-2.—Drawing perpendicular parallel lines. 11.204X

Before using the flat steel square, or at least at periodic intervals, see that you check it for accuracy as shown in figure 5-3. When the square is off, your work will be proportionately off, no matter how careful you are.

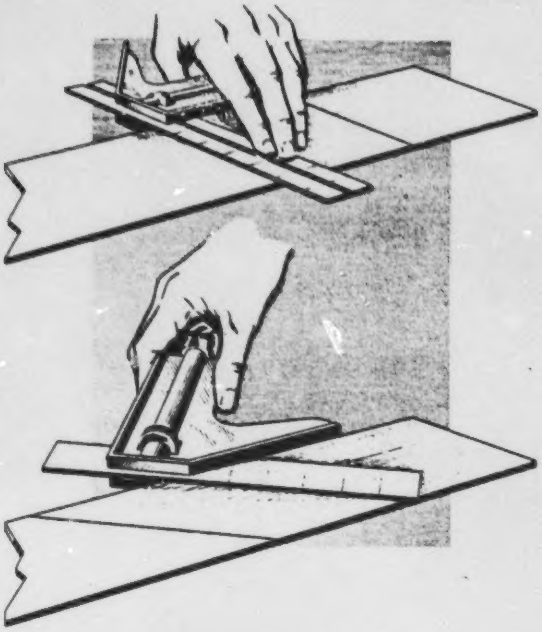


11.203X
Figure 5-3.—Checking the square.

The COMBINATION SQUARE can be used to draw a similar set of lines, as illustrated in figure 5-4. An edge of the metal upon which you are working is used as the baseline, as you will note in the illustration. One edge of the head of the combination square is 90° and the other edge is 45°.

Combination squares are delicate instruments and will be of little value if you permit them to receive rough handling. Stow your squares properly when you have finished using them. Keep them clean and in tiptop shape, and you will be able to construct 90° angles, 45° angles, and parallel lines without error.

To construct angles other than 45° or 90°, you will need a PROTRACTOR. Mark the vertex of the angle on your baseline with a prick punch (see fig. 5-5). Set the vertex of your protractor on the mark, and then scribe a V at the desired angle (in this case 70°). Scribe the line between the vertex and the point located by the V, and you have constructed an angle of 70°.

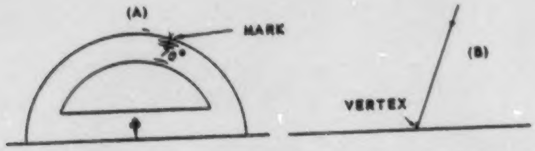


11.205
Figure 5-4.—Using combination square.

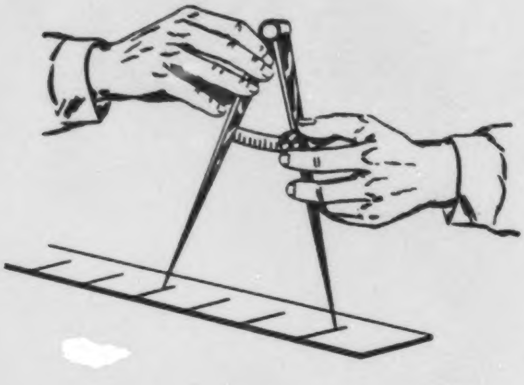
When you locate a point and mark it with the PRICK PUNCH, be sure to use very light taps with a small ballpeen hammer. The smaller the mark you make (so long as it is visible), the more useful and accurate that mark becomes.

You will use DIVIDERS to scribe arcs and circles, to transfer measurements from a scale to your layout, and to transfer measurements from one part of the layout to another. Careful setting of the dividers is of prime importance. When you transfer a measurement from a scale to the work, set one point of the dividers on the mark and accurately adjust the other leg to the desired length as illustrated in figure 5-6.

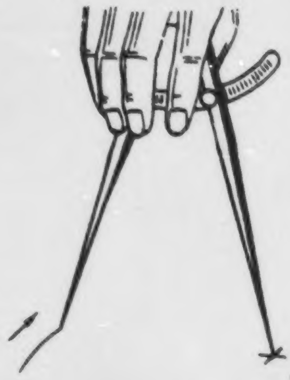
To scribe a circle, or an arc, grasp the dividers between the fingers and the thumb as illustrated in figure 5-7. Place the point of one leg on the center, and swing the arc. Exert enough pressure to hold the point on center, slightly inclining the dividers in the direction in which they are being rotated.



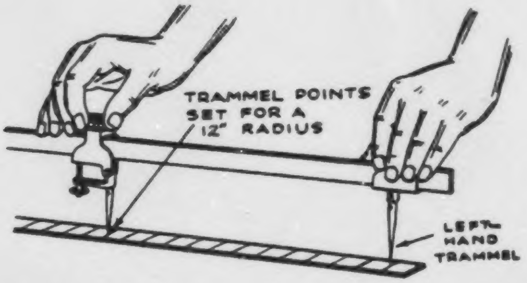
11.206X
Figure 5-5.—Constructing an angle with the protractor.



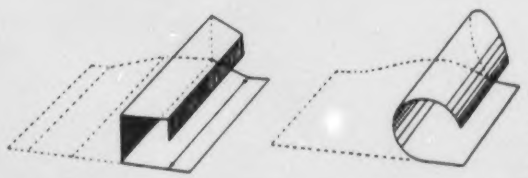
11.207
Figure 5-6.—Setting the dividers.



11.208X
Figure 5-7.—Scribing an arc or a circle with dividers.


TRAMMEL POINTS SET FOR A 12" RADIUS
LEFT-HAND TRAMMEL

11.209X
Figure 5-8.—Setting trammel points.



11.210X
Figure 5-9.—Forming square and cylindrical shapes from flat patterns.

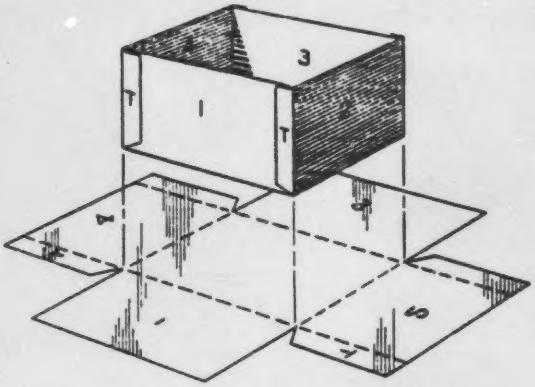
To scribe a circle with a radius larger than your dividers, the tool to select is the TRAMMEL POINTS. The technique of adjusting the points, as indicated in figure 5-8, is to set the left-hand point on one mark, slide the right-hand point to the desired distance, and tighten the thumbscrew. The arc, or circle, is then scribed in the same manner as with the dividers.

MAKING SIMPLE LAYOUTS

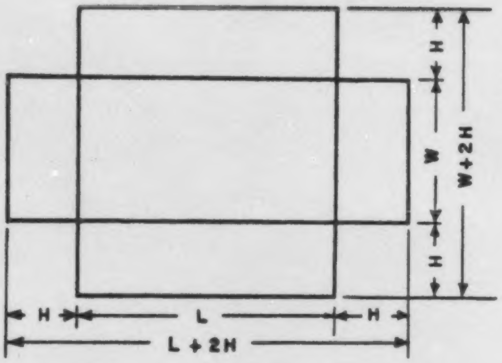
A STRETCHOUT is a pattern on a flat sheet which has not been formed. If a flat sheet is laid out to the correct shape and size, it may be formed into a three-dimensional object. Figure 5-9 shows three-dimensional objects being formed from flat patterns. When jobs are laid out, allowances for edges and seams must be added.

MAKING A DRIP PAN is a sheet metal job that you are sure to have if you are assigned as a striker in the sheet metal section of the steel shop. Some of these pans, or boxes, will be used around the machinery in your shops. Take a look at them and see how they were made. Some have had the seams welded. Others are riveted and soldered. The welded seam is the fastest and easiest to lay out, but the riveted and soldered seam is by far the better of the two in sheet metal work. The various methods of seaming are discussed later in this chapter.

Break out your layout tools. Select a piece of sheet metal or template paper about 1 foot square. Lay out a pan, or box, similar to that shown in figure 5-10. Make the sides about 1 1/2 inches in height, and the bottom about 9 inches square. Don't forget the tab for riveting. The angle on the tab is 45°. (See the flaps marked "T" in fig. 5-11). If this angle were not cut, you would have difficulty forming the side of the box. When you have the drip pan, or box, laid out, form the pan by breaking (bending) the sides up 90°. If you have made all of your measurements accurately, and have made your breaks on the line, the upper edge will be even all around, like the one shown in figure 5-11.

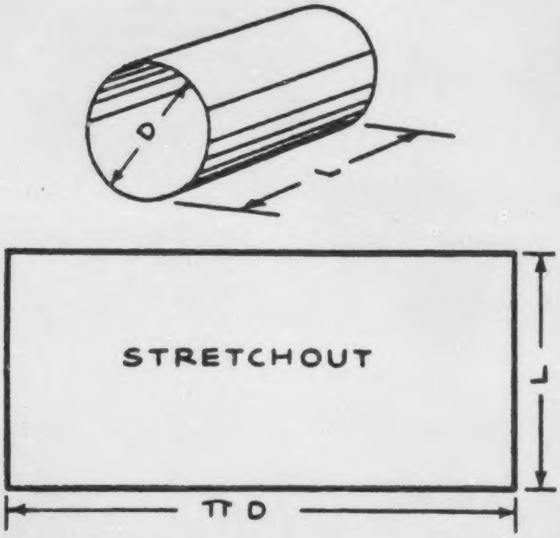


11.212
Figure 5-11.—Layout of box.



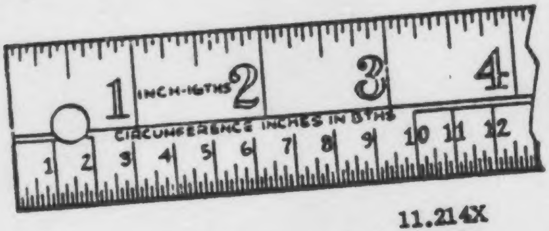
11.211X
Figure 5-10.–Dimensions for a box or drip pan layout.

THE STRETCHOUT OF A CYLINDRICAL JOB will be rectangular in shape, as shown in figure 5-12. One dimension of the rectangle will be the height of the cylinder, and the other dimension will be the circumference of the cylinder. When you're given measurements for a cylindrical job, however, you may be given the diameter rather than the circumference of the cylinder. You'll have to find the circumference yourself.



11.213X
Figure 5-12.—Stretchout of a cylinder.

One method of determining circumference is by computation or with a circumference rule. You remember that the circumference of a circle is equal to 3.1416 times the diameter (C=πD). By the use of this formula you can find the length of the stretchout of any cylindrical object. Just multiply the diameter by 3.1416 (or you can use 3.14 or 3 1/7, depending on how accurate you wish to be), and the answer will give you one dimension for the stretchout. To find out what part of an inch the decimal is, multiply that number by the denominator of the tolerance required. Suppose your circumference came out to 9.678'' and the tolerance is ± /16''. The 9 is in inches and the .678 is a decimal fraction of an inch. Now multiply .678 by 16

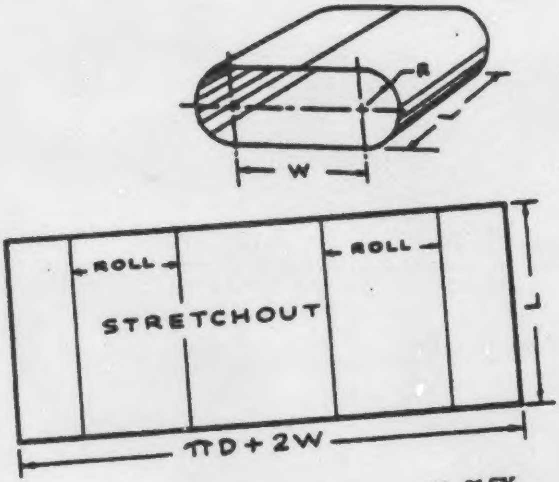


11.214X

Figure 5-13.—Circumference rule.

and you get 10.848, which is rounded off to 11. Since you come up with 11, put this over 16 and you have 11/16th of an inch. The length of the desired cylinder is the other dimension.

Another method of determining circumference is by use of the circumference rule. The upper edge of the circumference rule is graduated in inches in the same manner as a regular layout scale, but the lower edge is graduated as shown in figure 5-13. The lower edge gives you the approximate circumference of any circle within the range of the rule. You will notice in figure 5-13 that the reading on the lower edge directly below the 3-inch mark is a little over 9 3/8 inches. This reading would be the circumference of a circle with a diameter of 3 inches and would be the length of a stretchout for a cylinder of that diameter. The dimensions for the stretchout of a cylindrical object, then, are the height of the cylinder and the circumference. Don't forget that you'll have to allow for the seams.



11.215X

Figure 5-14.—Variation of a cylinder.

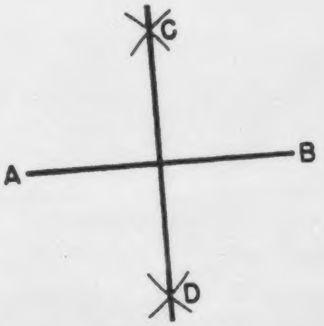
A VARIATION OF THE CYLINDRICAL JOB that you'll run into is a flat-sided structure with rounded ends. Such a shape is shown in figure 5-14.

To figure the stretchout for this shape, find the circumference of a completed circle of the diameter of such a circle as would be formed by the two curved ends of the shape. Then add twice the length of the straight part—W in figure 5-14. Use the following equation for figuring the unknown dimensions: $\pi D+2W$. The symbol π is always 3.1416. Here is an example: let D=5 and W=6. Now, 3.1416 x 5 + (2x6) = 27.7080, or about 27 3/4 inches, and the other will be the length of the shape that you are making.

USING GEOMETRY FOR LAYOUTS

CONSTRUCTING A 90° OR RIGHT ANGLE is not difficult if you have a true steel square. But suppose that you have no square, or that you have a square which is off. You still need a right angle for the layout. Break out your dividers, a scriber, and a straightedge. Draw a baseline like the one labeled AB in figure 5-15. Set the dividers for a distance greater than one-half AB; then with A as a center, scribe arcs like those labeled C and D. Now, without changing the setting of the dividers, use B as a center, and scribe another set of arcs at C and D. Draw a line through the points where the arcs intersect and you will have erected perpendiculars to line AB, forming four 90° or right angles. You will also have bisected or divided line AB into two equal parts.

CONSTRUCTING A RIGHT ANGLE AT A GIVEN POINT with a pair of dividers is a trick



11.216

Figure 5-15.—Constructing a 90° angle by bisecting a line.

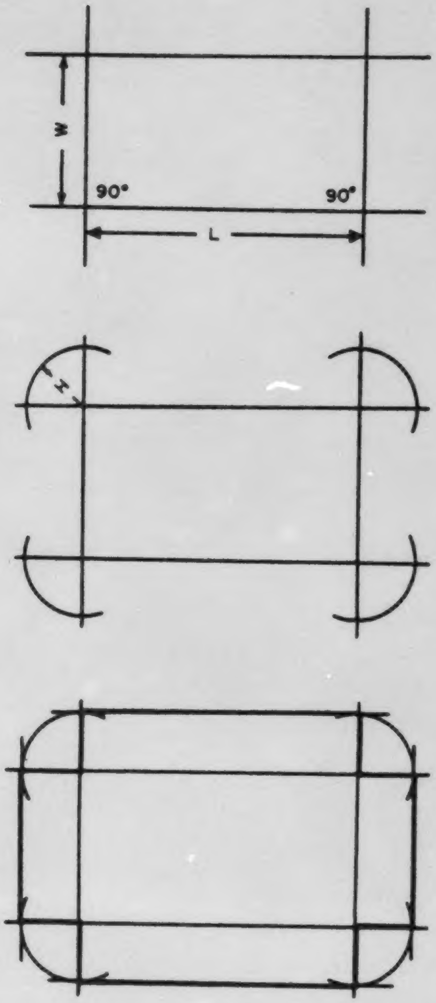
that you'll find quite useful in making layouts. Figure 5-16 is an illustration of a method for constructing a right angle at a given point.

Suppose that you have line XY with A as a point at which you need to erect a perpendicular to form a right angle. Select any convenient point which falls somewhere within the proposed 90° angle. In figure 5-16 that point is C. Using C as the center of a circle, with a radius equal to CA, scribe a semicircular arc as shown in figure 5-16. Lay a straightedge along the points B and C and draw a line which will intersect the other end of the arc at D. Now, draw a line connecting the points D and A and you have constructed a 90° angle. This method may be used to form 90° corners in stretchouts that are square or rectangular, like a drip pan or a box.

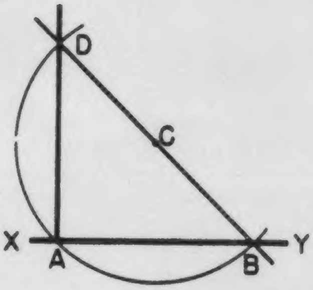
LAYING OUT A DRIP PAN WITH A PAIR OF DIVIDERS is no more difficult than erecting a perpendicular. You'll need dividers, scriber, straightedge, and a sheet of template paper. You know the dimensions, the length, width, and height or depth to which the pan must be made. Draw a baseline (see fig. 5-17). Select a point on this line for one corner of the drip-pan layout. Erect a perpendicular through this point forming a 90° angle.

Next, measure off on the baseline the required length of the pan. At this point erect another perpendicular. You now have three sides of the stretchout. Using the required length of the pan for the other dimensions, draw the fourth side parallel to the baseline, connecting the two perpendiculars that you have erected.

Now, set the dividers for marking off the depth of the drip pan. You can use a steel scale to measure off the correct radius on the dividers. Using each corner for a point, swing a wide arc like the one shown in the second step in figure 5-17. Extend the end and side lines as shown in the last step in figure 5-17, and complete the stretchout by connecting the arcs with a scriber and straightedge. The next step is to lay out tabs like those shown in figure 5-11. Their size is determined by the diameter of the rivet, which in turn is determined by the thickness of the sheet. All that remains to be done now is to transfer the pattern to the sheet, cut the metal, and form it.



11.218X
Figure 5-17.—Laying out a drip pan with dividers.

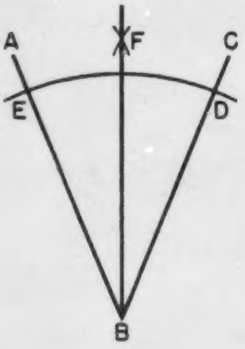


11.217
Figure 5-16.—Constructing a 90° angle at a given point.

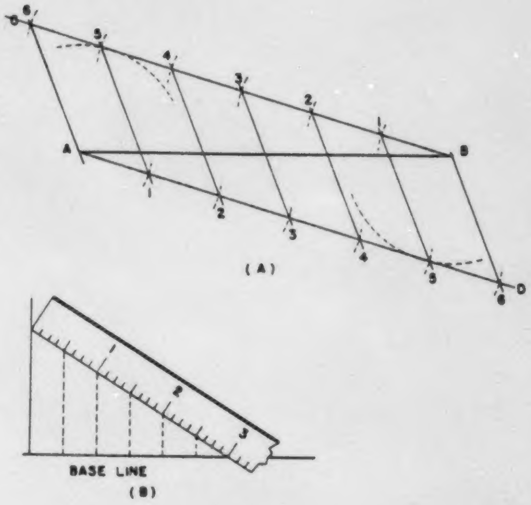
You have seen how a pan can be laid out without the use of a steel square by the use of geometric constructions. You bisected a line, erected a perpendicular from a given point on a line, and drew parallel lines by geometric construction. You'll find that these and other geometrical principles may be used to do a lot of layout problems rapidly and accurately.

BISECTING AN ARC is another geometric construction with which you should be familiar. Angle ABC (see fig. 5-18) is given. With B as a center, draw an arc cutting the sides of the angle at D and E. With D and E as centers, and with a radius greater than half of arc DE, draw arcs intersecting at F. A line drawn from B through the point F bisects the angle ABC.

Two methods used to DIVIDE A LINE INTO A GIVEN NUMBER OF EQUAL PARTS are illustrated in figure 5-19. When the method shown in view A is to be used you will need a straightedge and dividers. In using this method, draw line AB to the desired length. With the dividers set at any given radius, use point A as center and scribe an arc above the line. Using the same radius and B as center, scribe an arc below the line as shown. From point A, draw a straight line tangent to the arc which is below point B. Do the same from point B. With the dividers set at any given distance, start at point A and step off the required number of spaces along line AD using tick marks—in this case, 6. Number the tick marks as shown. Do the same from point B along line BC. With the straightedge, draw lines from point 6 to point A, 5 to 1, 4 to 2, 3 to 3, 2 to 4, 1 to 5, and B to 6. You have now divided line AB into six equal parts.



11.219
Figure 5-18.—Bisecting an angle.



11.220(127E)
Figure 5-19.—Two methods used to divide a line into equal parts.

When the method shown in view B of figure 5-19 is used to divide a line into a given number of equal parts, you will need only a scale. In using this method, draw a line at right angles to one end of the base line. Place the scale at such an angle that the number of spaces required will divide evenly into the space covered by the scale. In the illustration (view B, fig. 5-19) the baseline is 2 1/2'' and is to be divided into six spaces. Place the scale so that the 3'' will cover 2 1/2'' on the baseline. Since 3'' divided by 6 spaces = 1/2'', draw lines from the 1/2'' spaces on the scale perpendicular to the baseline. Incidentally, you may even use a full 6 inches in the scale by increasing its angle of slope from the baseline and dropping perpendiculars from the full-inch graduation to the baseline.

TO DIVIDE OR STEP OFF THE CIRCUMFERENCE OF A CIRCLE into six approximately equal parts, just set the dividers for the radius of the circle and select a point of the circumference for a beginning point. In figure 5-20, point A is selected for a beginning point. With A as a center, swing an arc through the circumference of the circle like the one shown at B in the illustration. Use B, then, as a point, and swing an arc through the circumference at C. Continue to step off in this manner until you have divided the circle

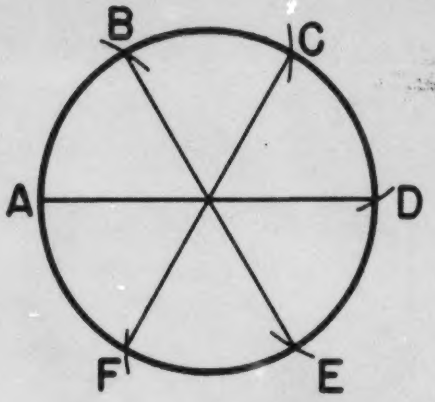


Figure 5-20.—Dividing a circle into six equal parts. 11.221

into six equal parts. If the points of intersection between the arcs and the circumference are connected as shown in figure 5-20, the lines will intersect at the center of the circle, forming angles of 60°.

If you need an angle of 30°, all you have to do is to bisect one of these 60° angles, by the method described earlier in this chapter. Bisect the 30° angle and you have a 15° angle. You can construct a 45° angle in the same manner by bisecting a 90° angle. In all probability, you'll have a protractor to lay out these and other angles. But just in case you don't happen to have a steel square or protractor, it's a good idea to know how to construct angles of various sizes and to erect perpendiculars.

LAYING OUT A SQUARE OR RECTANGULAR ELBOW WITH A PAIR OF DIVIDERS is another job in which you will use geometric construction.

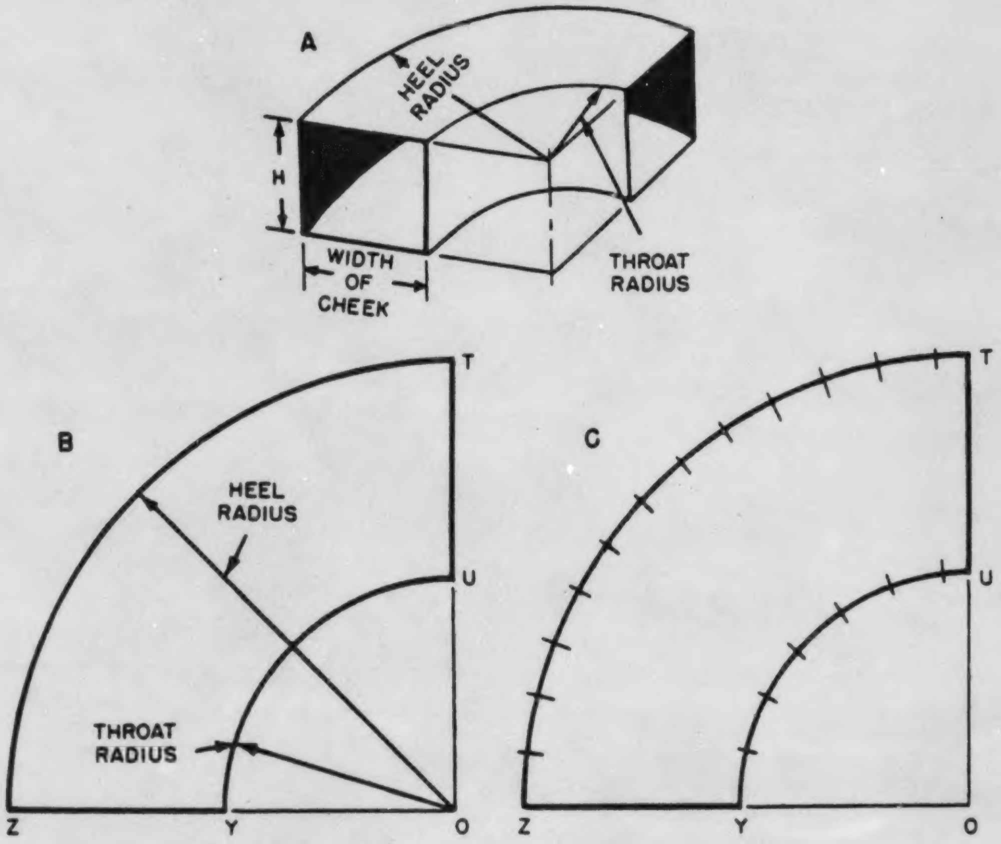


Figure 5-21.—Layout of square or rectangular elbow. 11.222X

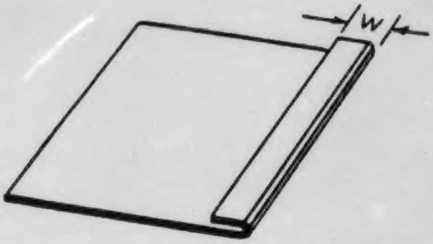
Take a look at figure 5-21. View A in the illustration shows you what the completed job should look like. Now, to make your layout for this job, draw the baseline OZ shown in view B of the illustration. Set the dividers for a distance equal to the width of the cheek. This distance forms the throat radius. This rule will not always apply, as it must often be governed by the amount of space available to make the turn with the elbow. Now, with O as a center, scribe the arc YU. To get the heel radius, add the width of the cheek to the throat radius. Using O as a center, scribe the arc ZT. These layouts, when cut, will form the cheeks, or sides, of the elbow.

The next operation is to lay out the heel and throat pieces. These are the other two of the four sides of the elbow, the throat being the inside piece, and the heel the outside piece. Set the dividers at exactly 1 inch, and step off the heel and throat arcs as shown in view C, figure 5-21. If there is a distance of less than 1 inch left at the end of the arc, measure it with another pair of dividers or a scale. To make the stretchout of the heel and throat, lay out one piece of metal equal to the height of the elbow (see view A, fig. 5-21) and equal in length to the number of steps taken with the dividers, plus the fraction of an inch left over. One stretchout will be the heel and the other the throat. You can assemble this elbow by welding, in which case you won't need to allow for tabs. But welding will cause a thin section to warp, so you may need to use one of the other standard methods for joining this type of work.

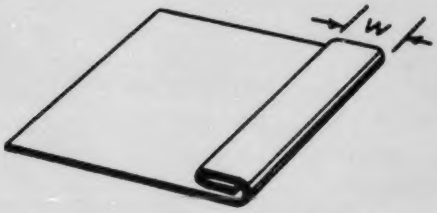
ALLOWING FOR EDGES

Thus far your practice jobs have been laid out to be formed with the edges left as they are. Very few of your jobs in the shop will actually be fabricated in this manner. Edges are formed to improve the appearance of the work, strengthen the piece, or to eliminate the raw edge. These edges may be formed from the metal itself by inserting wire, or by attaching a band or angle iron. The kind of edge that you will use on any job will be determined by the purpose, size, or strength of the edge needed.

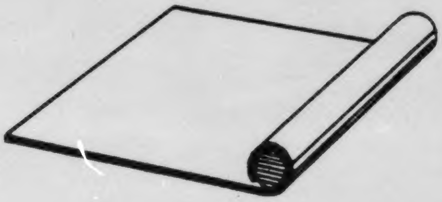
THE SINGLE-HEM EDGE is illustrated in figure 5-22. This edge can be made in any width. In general, the heavier the metal, the wider the hem is made. The allowance for the hem is equal to its width (W in fig. 5-22).



11.223X
Figure 5-22.—Single-hem edge.



11.224X
Figure 5-23.—Double-hem edge.



11.225X
Figure 5-24.—Wired edge.

THE DOUBLE-HEM EDGE (fig. 5-23) is used where additional strength is needed, or when a smooth edge is desired inside as well as outside. The allowance for the double-hem edge is twice the width of the hem.

A WIRED EDGE (fig. 5-24) will often be specified in plans. Objects such as ice-cube trays, funnels, garbage pails, and other articles formed from sheet metal are manufactured with wired edges to strengthen and stiffen jobs and eliminate sharp edges. The allowance for a wired edge is 2 1/2 times the diameter of the wire used. For example, if you are using wire which has a diameter of 1/8 inch, multiply 1/8 by 2 1/2 and your answer will be 5/16 inch, which you will allow when laying out sheet metal for making the wired edge.

3-24 181

CHAPTER 6

PLATE AND PIPE LAYOUT AND FABRICATION

In addition to sheet metal, Steelworkers also are required to layout and fabricate plate metal. Plate layout procedures are essentially the same as those for sheet metal, which were covered in the preceding chapter. There are, however, some aspects of plate metal fabrication which merit a separate discussion. Plate metal is generally much thicker than sheet metal and is, therefore, more difficult to work and form. The first part of this chapter will, therefore, be devoted to examining the techniques necessary to cut, form, and join plate metal.

Steelworkers must also be able to layout and fabricate piping or piping systems, such as might be used in a tank farm project. The remaining portions of the chapter will discuss procedures for cutting, bending, and joining pipe, and layout operations peculiar to the fabrication of piping systems. Specific torch cutting and welding techniques carried out in the various stages of both plate and pipe fabrication will be covered in greater detail in later chapters on welding.

FABRICATING PLATE

Some aspects of plate fabrication which differ from the procedures previously described in chapter 5 for sheet fabrication are discussed in the following sections.

CUTTING PLATE

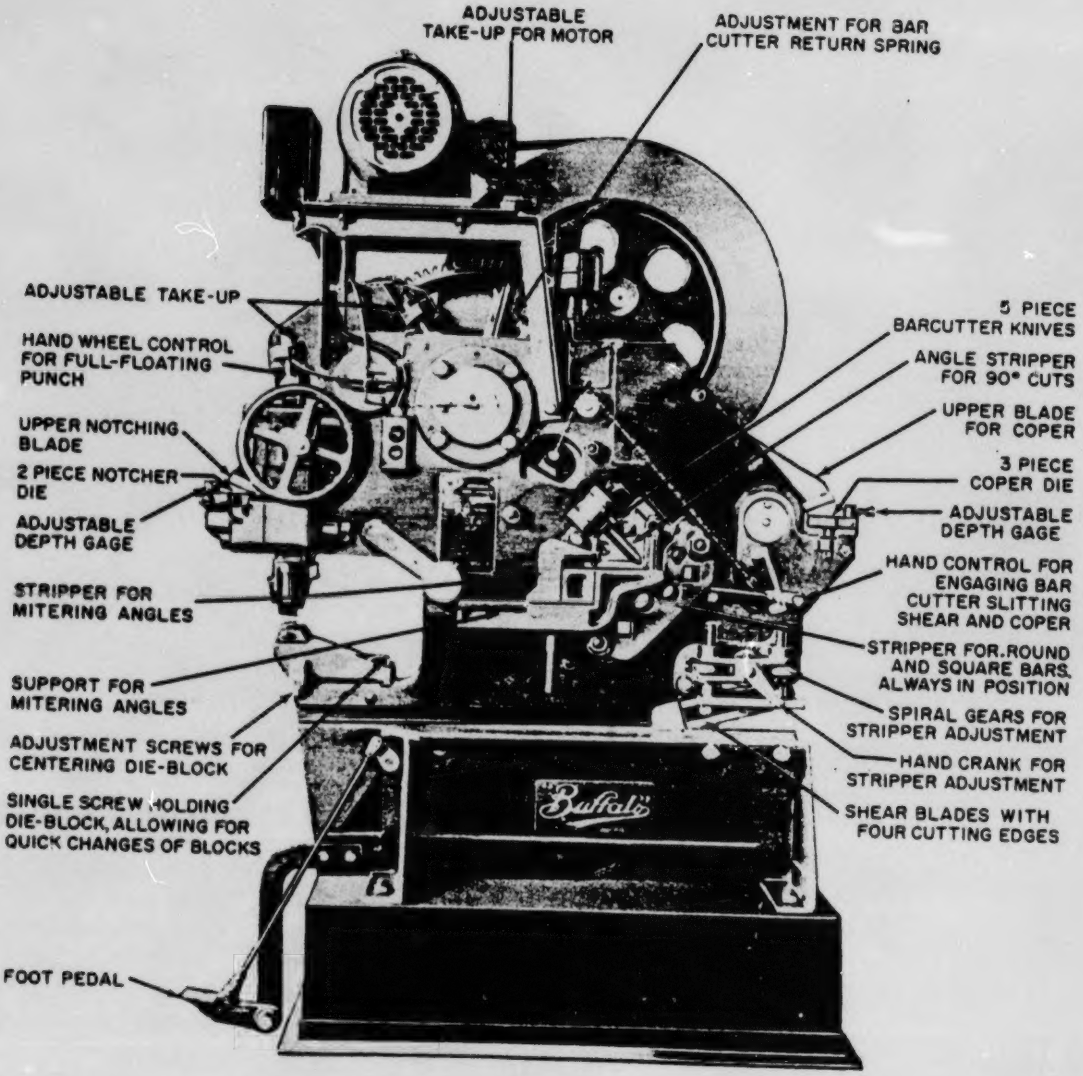
Perhaps the most common method of cutting plate is to use the gas (either oxyacetylene or OXY-MAPP gas) cutting torch, as described in chapter 9 of this training manual. However, plate may also be cut with various tools and machines. Some power saws may be used to cut plate. The heavy-duty slitting shear shown in figure 6-1 is useful for cutting very heavy sheet, light plate, strap iron, and flat bar stock. The power-driven machine shown in figure 6-2 is known as a combination punch, shear, and coper. This machine has several attachments, including devices for slitting, notching, and coping. With this machine (as, in fact, with all machines used for working metal) you must be careful not to exceed the rated capacity specified by the manufacturer.

FORMING PLATE

The machines used for bending plate are similar to the machines used for bending sheet but are designed to take greater thicknesses of metal. Most machines used for plate work are power driven. Figure 6-3 shows a large slip-roll forming machine used for bending plate.

11.300

Figure 6-1.—Heavy-duty slitting shear.

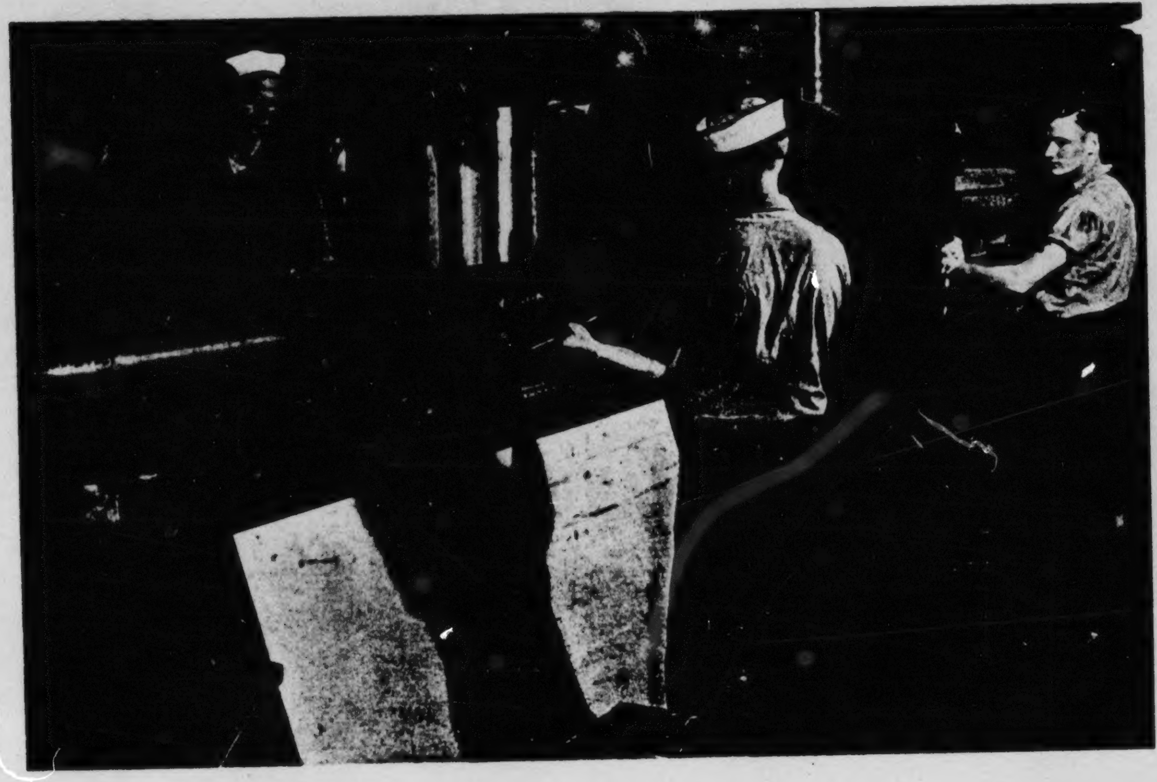

ADJUSTABLE TAKE-UP FOR MOTOR
ADJUSTMENT FOR BAR CUTTER RETURN SPRING
ADJUSTABLE TAKE-UP
HAND WHEEL CONTROL FOR FULL-FLOATING PUNCH
UPPER NOTCHING BLADE
2 PIECE NOTCHER DIE
ADJUSTABLE DEPTH GAGE
STRIPPER FOR MITERING ANGLES
SUPPORT FOR MITERING ANGLES
ADJUSTMENT SCREWS FOR CENTERING DIE-BLOCK
SINGLE SCREW HOLDING DIE-BLOCK, ALLOWING FOR QUICK CHANGES OF BLOCKS
FOOT PEDAL
5 PIECE BARCUTTER KNIVES
ANGLE STRIPPER FOR 90° CUTS
UPPER BLADE FOR COPER
3 PIECE COPER DIE
ADJUSTABLE DEPTH GAGE
HAND CONTROL FOR ENGAGING BAR CUTTER SLITTING SHEAR AND COPER
STRIPPER FOR ROUND AND SQUARE BARS, ALWAYS IN POSITION
SPIRAL GEARS FOR STRIPPER ADJUSTMENT
HAND CRANK FOR STRIPPER ADJUSTMENT
SHEAR BLADES WITH FOUR CUTTING EDGES
Buffalo

11.301X
Figure 6-2.—Combination punch, shear, and coper.

Figure 6-4 shows a power bending brake that can be used for forming plate.

Although plate is usually bent on power bending machines, it can be heated and then hammered into shape. Also, it is sometimes possible to heat small sections of plate or bar stock and then bend them on a pipe bending slap.

One layout problem that is particularly important in plate work should be noted at this point. Regardless of the method to be used for bending plate, you must always consider the thickness of the plate and provide an adequate BEND ALLOWANCE. The amount of material which is actually used in forming the bend is



11.302

Figure 6-3.—Slip-roll forming machine for bending plate.

known as the bend allowance. The thicker the metal, the more important is the calculation of the bend allowance. In working with thin sheet, you can estimate (or sometimes even disregard) the thickness of the material. In working with heavy plate, neglecting the thickness of the material would cause serious deviations from specified dimensions and perhaps even complete lack of fit between component parts.

Bending compresses the metal on the inside of the bend, and stretches the metal on the outside of the bend. Halfway between these two surfaces or extremes lies a space that neither shrinks nor stretches, but retains the same length. This is the neutral axis. Figure 6-5 illustrates the neutral axis of a bend. It is along this neutral axis that the bend allowance is computed.

Bend Allowance Terms

In order for you to more thoroughly understand the calculation and discussion of bend allowance, you should become familiar with the following terms. As you study the following terms, refer to figure 6-6 and locate each part described.

Leg—The longer part of a formed angel.

Flange—The shorter part of a formed angle. If both parts are the same length, each is known as a leg.

Mold Line (ML)—The line formed by extending the outside surfaces of the leg and flange so that they intersect.

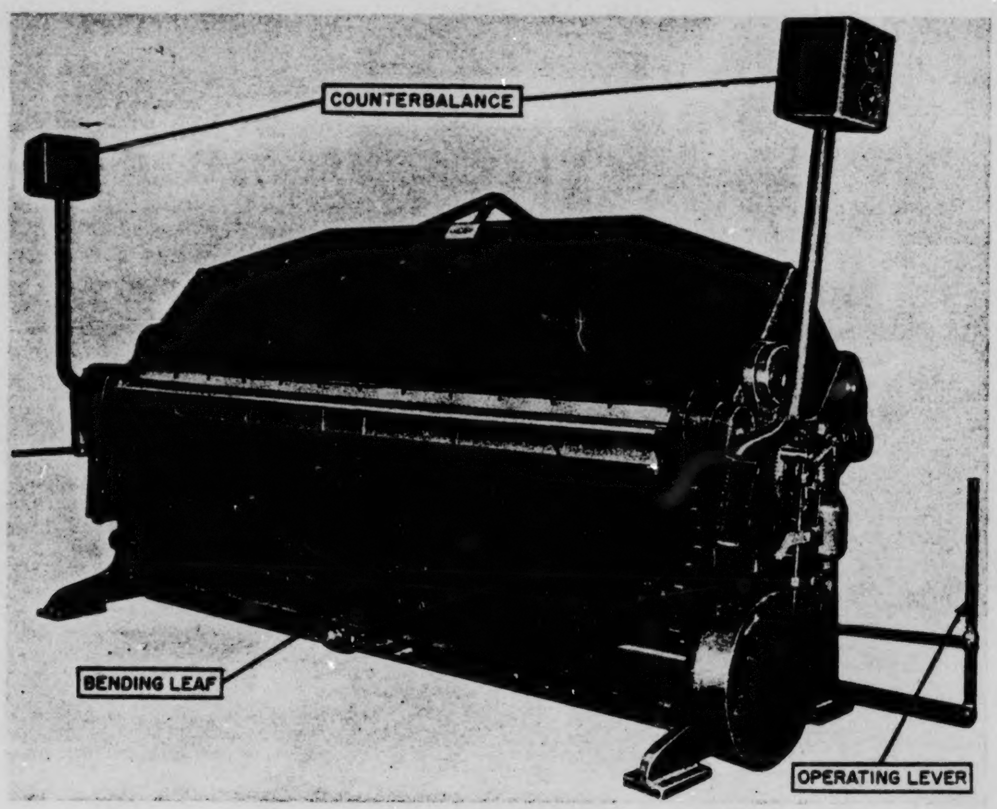

COUNTERBALANCE
BENDING LEAF
OPERATING LEVER

Figure 6-4.—Power bending brake for plate work. 11.303X

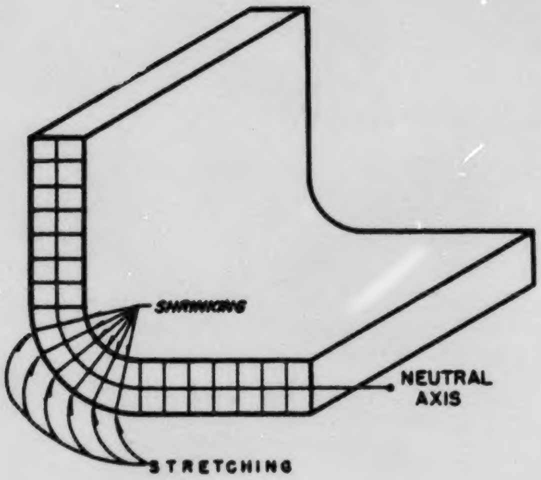
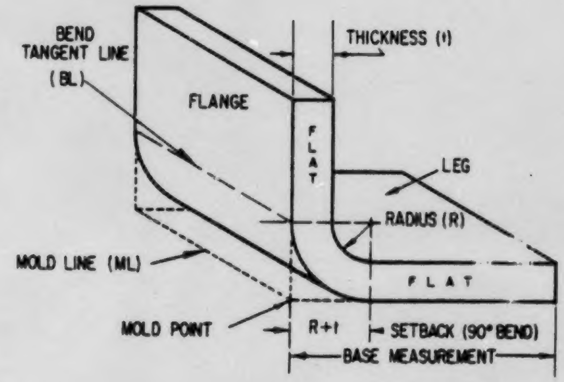

SHRINKING
NEUTRAL AXIS
STRETCHING

Figure 6-5.—Neutral axis. 11.304.1


BEND TANGENT LINE (BL)
THICKNESS (t)
FLANGE
FLAT
LEG
RADIUS (R)
MOLD LINE (ML)
FLAT
MOLD POINT
R+t
SETBACK (90° BEND)
BASE MEASUREMENT

11.304.2
Figure 6-6.—Bend allowance terms.

Bend Tangent Line (BL)—The line at which the metal starts to bend.

Bend Allowance (BA)—The amount of material consumed in making the bend.

Radius (R)—The radius of the bend. It is always measured from the inside of the bend unless otherwise stated.

Setback (SB)—The amount that the two mold line dimensions overlap when they are bent around the formed part. In a 90° bend, SB = R + T (radius of the bend plus thickness of the metal).

Bend Line (also called Brake or Sight Line)—The layout line on the metal being formed. It is set even with the nose of the cornice brake and serves as a guide in bending the work. (Before forming a bend, it must be decided which end of the material can be most conveniently inserted in the brake.) The bend line is then measured and marked with a soft pencil, from the bend tangent line closest to the end which is to be placed under the brake. This measurement should be equal to the radius of the bend. The metal is then inserted in the brake so that the nose of the brake will fall directly over the bend line.

Flat Portion or Flat—The flat portion or flat of a plate is that portion not included in the bend. It is equal to the base measurement minus the setback.

Base Measurement (or Mold Line Measurement)—The base measurement is the outside dimensions of a formed plate. Base measurement will be given on the blueprint or drawing, or may be obtained from the original part.

Closed Angle—An angle that is less than 90° when measured between legs, or more than 90° when the amount of bend is measured.

Open Angle—An angle that is more than 90° when measured between legs, or less than 90° when the amount of bend is measured.

Computing Bend Allowance

In order to compute bend allowance, two primary facts must be known; the radius of the bend, and the degree of angle in the bend. Usually, each of these factors can be determined from the blueprints or drawings from which you are working.

As you study the following examples refer to figure 6-7 to help you understand where and how the mathematical figures are obtained. Remember, bend allowance is MEASURED from the inside of the bend; but bend allowance is COMPUTED along the neutral axis of the material being used. Therefore, when calculating bend allowance, add the bend radius to one-half of the thickness of the metal, to determine the radius of the neutral axis.

Bend allowance is the produce of the radius of the neutral axis of the bend, and the size of the bend in radians. The radian relates the length of the arc generated to the size of the angle. For the purpose of computing bend allowance, the number of radians per degree of bend is 0.017453. Thus the formula for bend allowance is:

$$ba = r \times \theta$$

Where

ba = bend allowance

r = radius of the neutral axis of the bend

θ = size of the angle of the bend in radians

EXAMPLE 1 (fig. 6-7).—What is the bend allowance for a 90° bend which is to be made in plate that is 1/2 inch thick?

$r = 0.50 + 0.250 = 0.750$ inches

$\theta = 0.017453 \times 90 = 1.57$ radians

Therefore:

$ba = 0.750 \times 1.57 = 1.178$ or 1.18 inches

EXAMPLE 2 (fig. 6-8).—What is the bend allowance for a 180° bend which is to be made in a length of 1/2-inch stock?

$r = 1.0 + 0.250 = 1.25$ inches

$\theta = 0.017453 \times 180 = 3.14$ radians

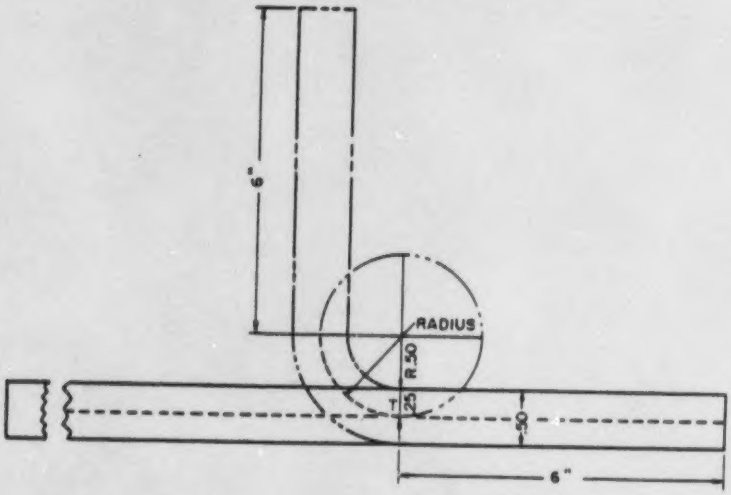
Therefore:

$ba = 1.25 \times 3.14 = 3.925$ inches

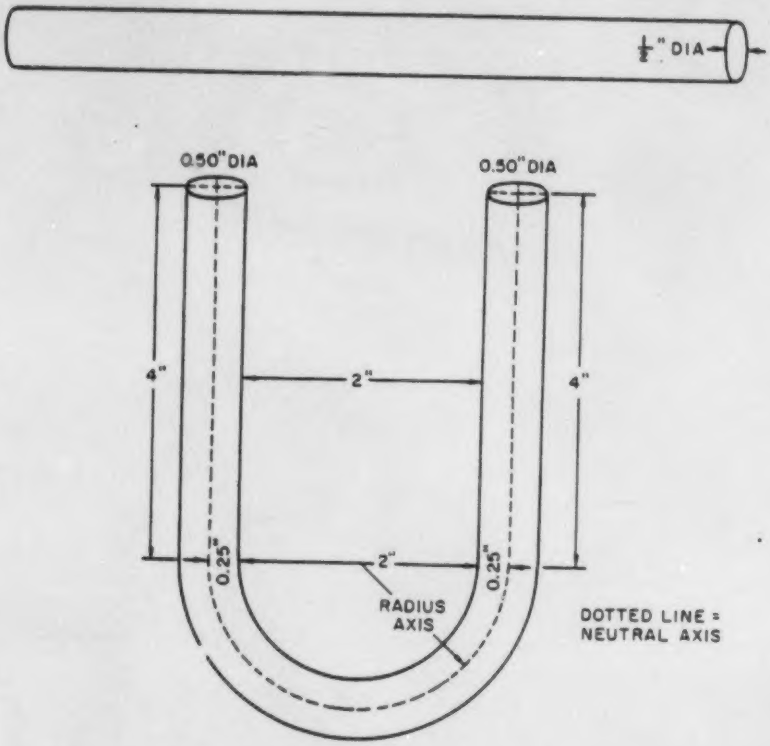
JOINING PLATE

The methods used to join plate include welding, brazing, and riveting. The method used in each case depends upon the composition of the material, the size and shape of the parts, the service for which the finished object is intended, and the number of other factors. In general, welding is the preferred method of joining plate.

Riveting was once widely used to join plate sections. Although it is not commonly used at the present time, it is still possible that you may be required to join plate by riveting or


6"
RADIUS
R.50
.25
T
.50
6"

11.304.3
Figure 6-7.—Bend allowance and length computation for a 90° L-shaped bracket.


1/2" DIA
0.50" DIA
0.50" DIA
4"
2"
4"
0.25"
2"
0.25"
RADIUS
AXIS
DOTTED LINE =
NEUTRAL AXIS

11.375
Figure 6-8.—Computing overall length of a U-bolt.

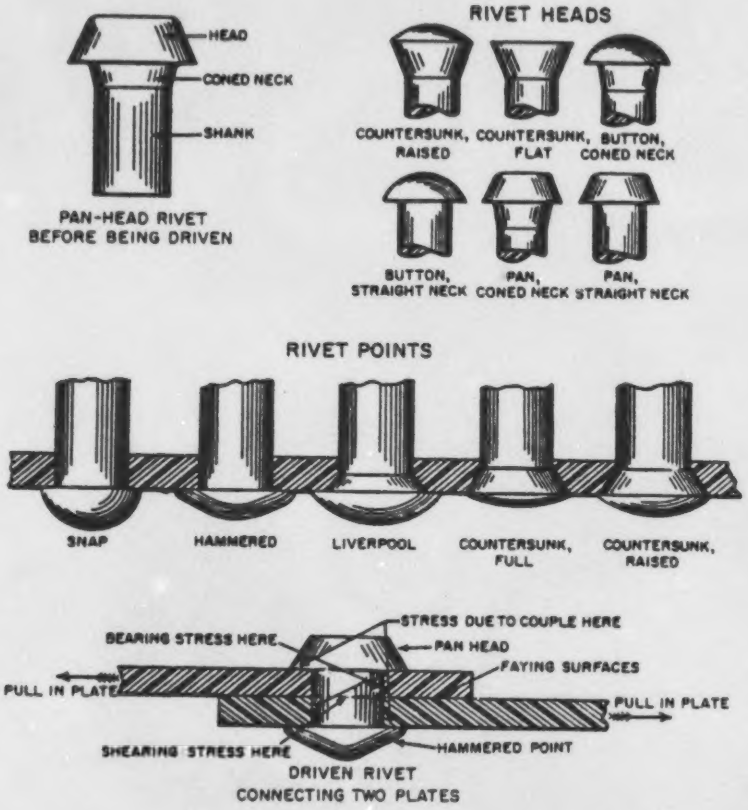
that you may have to burn out bad rivets and replace them in riveted structures. Most reveting of plate is done with hot rivets. In general, rivets used for joining plate should be of the same material as the plate.

The selection of rivets for plate work must be made on the basis of the load on the structure and other service conditions. Determining loads, selecting rivet materials and sizes, and designing riveted joints requires an extensive knowledge of properties of materials and of design standards. As a rule, you will work from specifications and blueprints or you will be told what size and type of rivets to use and what type of layout to make for the rivet holes. Figure 6-9 illustrates some types of rivets commonly used for joining plate and structural shapes.

Table 6-1 gives the rivet sizes commonly used for riveting plate under ordinary conditions; remember, however, that unusual loading or other unusual service conditions will affect the size of rivets required for the job.

Before riveting plate, clean the adjoining surfaces of the plate. Then bolt the sections of plate firmly together, putting the bolts through some of the rivet holes. After the rivets have been driven in the other rivet holes, remove the bolts and put in rivets.

Small rivets may be driven cold. Large rivets must be heated. Care must be taken to avoid overheating the rivets. A correctly heated rivet is light red in color when it is taken from the fire, and cherry red when it is driven. Figure 6-10 shows a rivet set up for driving. The length of the rivets should extend through the

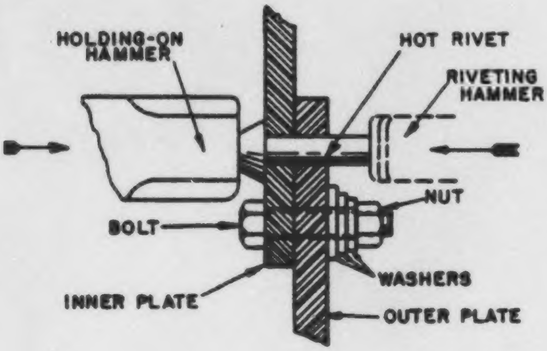

HEAD
CONED NECK
SHANK
PAN-HEAD RIVET BEFORE BEING DRIVEN
RIVET HEADS
COUNTERSUNK, RAISED
COUNTERSUNK, FLAT
BUTTON, CONED NECK
BUTTON, STRAIGHT NECK
PAN, CONED NECK
PAN, STRAIGHT NECK
RIVET POINTS
SNAP
HAMMERED
LIVERPOOL
COUNTERSUNK, FULL
COUNTERSUNK, RAISED
STRESS DUE TO COUPLE HERE
BEARING STRESS HERE
PAN HEAD
FAYING SURFACES
PULL IN PLATE
PULL IN PLATE
SHEARING STRESS HERE
HAMMERED POINT
DRIVEN RIVET CONNECTING TWO PLATES

11.305

Figure 6-9.—Types of rivets commonly used for joining plate and structural shapes.

11.392
ble 6-1.—Rivet Sizes Required For Various icknesses of Plate, Under Ordinary Conditions.

Rivet size (diameter, inches)	Plate thickness (inches)
1/4	Under 5/64
3/8	5/64 to 5/32
1/2	5/32 to 7/32
5/8	7/32 to 5/16
3/4	5/16 to 1/2
7/8	1/2 to 3/4
1	3/4 to 1
1 1/8	1 and over



11.306
Figure 6-10.—Rivet set up for driving.

metal a distance of 1-1/2 times the diameter to have sufficient metal to form the head.

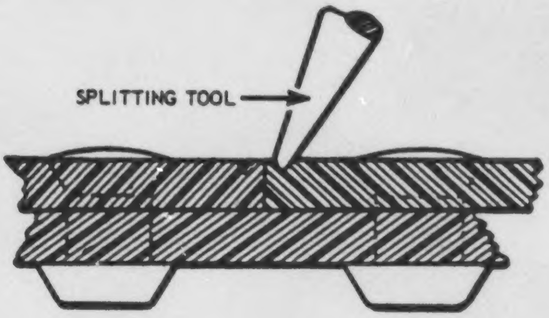
A procedure known as METAL CALKING is sometimes used to make riveted joints watertight. Metal calking consists of forming a groove or furrow with a splitting tool, as shown in figure 6-11, and then tamping the joint with a calking tool, as illustrated in figure 6-12. Metal calking should only be done from the side upon which pressure will be exerted—as, for example, from the inside of a tank.

CUTTING PIPE

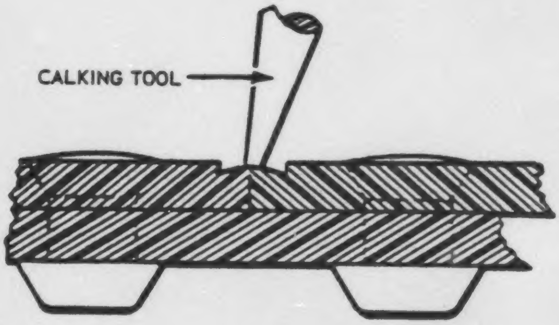
Cutting pipe is not much different than cutting structural shapes, except that you must always keep in mind that the cut will either be radial or miter.

The gas cutting torch is used to cut pipe fittings for welding. As we mentioned before, procedures relating to the use of the cutting torch are given in chapter 9. The torch may be hand-operated or it may be mounted on a mechanical device for more accurate control.

Cutting machines may be used to prepare many fittings without the use of templates. These



11.307
Figure 6-11.—Forming a groove for metal calking a joint.



11.308
Figure 6-12.—Tamping joint with metal calking tool.

machines cut and bevel the pipe in one operation, the bevel extending for the full pipe wall thickness. When pipe is cut by hand, beveling is done as a second operation.

For many types of welded fittings a RADIAL cut is required prior to beveling. Radial cutting simply means that the cutting torch is held so as to be perpendicular to the interior centerline at all times. In other words, the gas cutting orifice always forms a continuation of a radius of the pipe, making the cut edge square with the pipe wall at every point. Figure 6-13 illustrates radial cutting. Except in the case of the blunt bull plug, for which the radial cut provides the proper vee, the radial cut should be followed by a beveling cut for pipe with 3/16 inch or more wall thickness.

In MITER cutting the torch flame is held so that the entire cut surface is in the same plane. The miter cut is followed by a beveling cut, leaving 1/32 to 1/16 inch nose at the inner wall. Figure 6-14 illustrated miter cutting.

PIPE BENDING

Any piping system of consequence will have bends in it. When fabricating pipe for such a system, bends can be made by a variety of methods, either hot or cold, and either manually or on a power bending machine. Cold bends in pipe are usually made on a bending machine. Various types of equipment are available, ranging from portable handsets to large, hydraulically driven machines which can cold bend pipe up to 16-inches in diameter. You will be concerned primarily, however, with hot bending techniques, using a bending slab or employing a method known as wrinkle bending.

MAKING TEMPLATES

Whatever method you use to bend pipe, you should, ordinarily, have some pattern which represents the desired shape of the bend. Templates made from wire or small, flexible tubing can be invaluable in preparing new installations, as well as in repair work. When properly made, they will provide an exact guide to the bend desired.

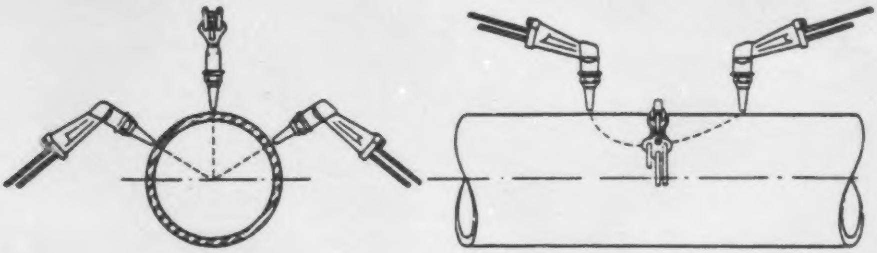
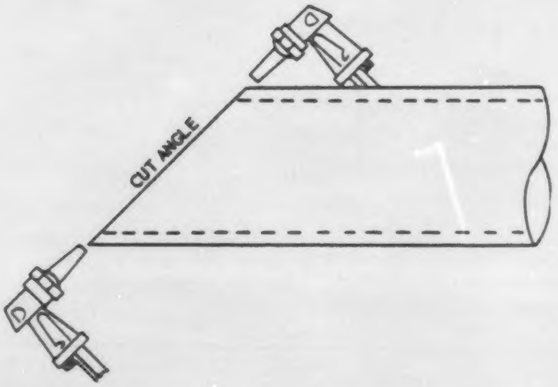
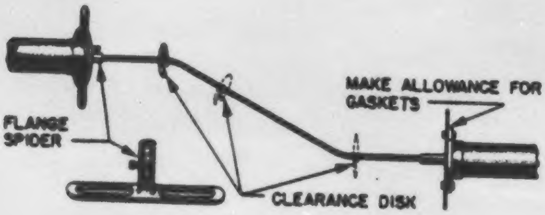


Figure 6-13.—Radial cutting. 145.179X



145.180X
Figure 6-14.—Miter cutting.

One of the simple types of bend template is the centerline template. A centerline template is made to conform to the bend, or bends, of the pipe to be made. It is used to lay off the bend area on the pipe, and as a guide during the pipe or tube bending operation. Figure 6-15 illustrates the use of a centerline template. These timplates are made of wire or rod, and are shaped to establish the centerline of the pipe to be installed; the ends of the wire are secured to special clamps, called flange spiders. A clearance disk, which must be the same diameter as the pipe,



11.344
Figure 6-15.—Centerline template.

is used if there is any doubt about the clearance around the pipe.

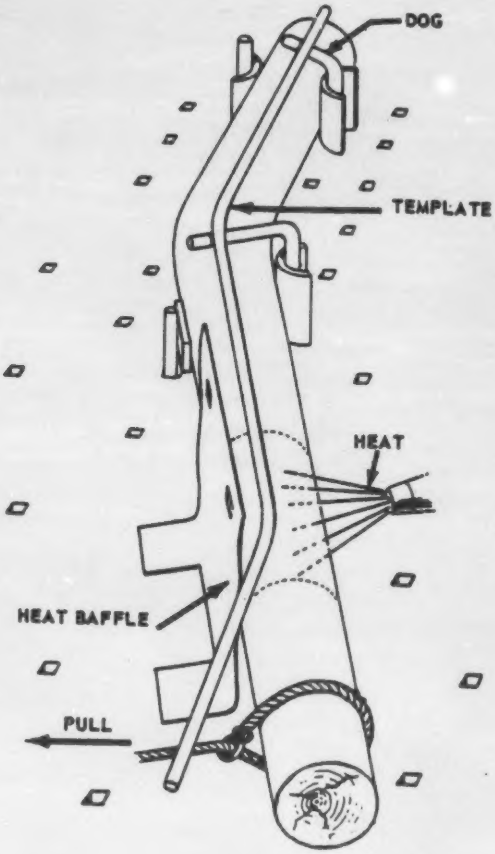
HOT BENDING

Hot bends are accomplished on a bending slab (fig. 6-16). This slab requires little maintenance beyond a light coating of machine oil to keep rust in check.

As a preliminary step in hot bending, pack the pipe with dry sand to prevent the heel or outside of the bend from flattening. If flattening occurs, it will reduce the cross-sectional area of the pipe, and restrict the flow of fluid through the system.

Drive a tapered wooden plug into one end of the pipe. Place the pipe in a vertical position with the plugged end down and fill it with dry sand, leaving just enough space at the upper end to take a second plug. To ensure that the sand is tightly packed, tap the pipe continually with a wooden or rawhide mallet during the filling operation. A good rule of thumb is to tap ONE HOUR for each inch of pipe diameter. The second plug is identical with the first, except that a small vent hole is drilled through its length; this vent permits the escape of any gases (mostly steam) which may form in the packed pipe when heat is applied. No matter how dry the sand may appear, there is always a possibility that some moisture is present. This moisture will form steam which will expand and build up pressure in the heated pipe, unless some means of escape is provided. If you do not provide a vent, you will almost certainly blow out one of the plugs before you get the pipe bent.

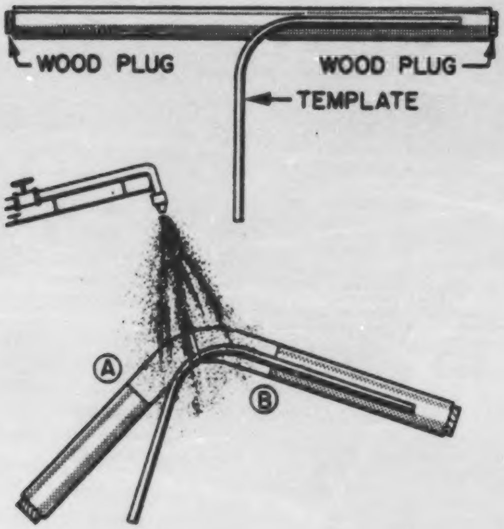
When you have packed the pipe with sand, the next step is to heat the pipe and make the bend. Mark the bend area of the pipe with chalk or soapstone and heat to an even red heat along the distance indicated from A to B in figure 6-17. Apply heat to the bend area first on the outside of the bend and then on the inside. When an even heat has been obtained, bend the pipe to conform to the wire template. The template is also used to mark the bend area on the pipe.



11.345
Figure 6-16.—Bending on a slab.

The main problem you will have in bending copper tubing and pipe is preventing wrinkles and flat spots. Wrinkles are caused by compression of the pipe wall at the throat (inside) of the bend. Flat spots are caused by lack of support for the pipe wall, by stretch in the heel (outside) of the bend, or by improper heating.

If the pipe is properly packed and properly heated, wrinkles and flat spots can be prevented by bending the pipe in segments so that the stretch is spread evenly over the whole bend area. When a pipe is bent, the stretch tends to occur at the middle of the bend. If the bend area is divided into a number of segments and then bent in segments, the stretch will occur at the

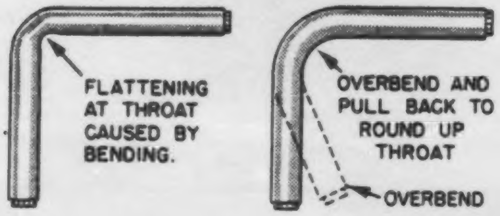


11.347
Figure 6-17.—Heating and bending pipe to conform to wire template.

center of each segment and thus be spread fairly evenly over the whole bend area. Another advantage of bending in segments is that this is about the only way you can follow a wire template accurately.

When bending steel and some other piping materials, you can control wrinkles and flat spots by first overbending the pipe slightly and then pulling the end back, as shown in figure 6-18.

Hot bends are made on a bending slab, as indicated in figure 6-16. The pull to make the bend is exerted in a direction parallel to the surface of the bending slab. The necessary leverage for forming the bend is obtained by using chain-falls or block-and-tackle, or by using a length of pipe which has a large enough diameter to slip over the end of the packed pipe. Bending pins and holddown clamps (dogs) are used to position the bend at the desired location.


FLATTENING AT THROAT CAUSED BY BENDING.
OVERBEND AND PULL BACK TO ROUND UP THROAT
OVERBEND

11.348
Figure 6-18.—Overbending to correct flattening of pipe.

Be sure to wear asbestos gloves when working on hot bending jobs. Pins, clamps, and baffles often have to be moved during the bending operation. These items absorb heat radiated from the pipe as well as from the torch flame itself; you cannot safely handle these bending accessories without gloves.

Each material has its peculiar traits, and you will need to know about these traits in order to get satisfactory results. The following hints for bending different materials should prove helpful:

WROUGHT IRON—This material becomes brittle when hot, so always use a large bend radius. Apply the torch to the throat of the bend instead of to the heel.

BRASS—Do not overbend, as brass is likely to break when the bend direction is reversed.

COPPER—Hot bends may be made in copper, although the copper alloys are more adaptable to cold bending. This material is one that is not likely to give any trouble.

ALUMINUM—Overbending and reverse bending do not harm aluminum, but because there is only a small range between the bending and melting temperatures, you will have to work with care. Keep the heat in the throat at all times. You will not be able to see any heat color, so you must depend on "feel" to tell you when the heat is right for bending. You can do this by keeping a strain on the pipe while the bend area is being heated. As soon as the bend starts, flick the flame away from the area. Play it back and forth to maintain the bending temperature and, at the same time, to avoid overheating.

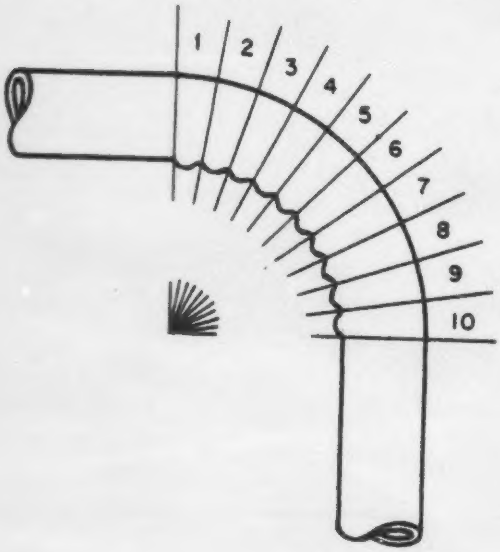
CARBON-MOLYBDENUM and CHROMIUM-MOLYBDENUM—These may be heated for bending, if necessary; however, caution must be exercised so as not to overheat the bend area because these types of metals are easily crystallized when extreme heat is applied. Pipes made from these materials should be bent cold in manual or power bending machines.

WRINKLE BENDING

It may seem odd that after describing precautions necessary to keep a bend free of wrinkles, we next describe a method which deliberately produces wrinkles as a means of bending the pipe. Nevertheless, you will find the wrinkle bending technique a simple and direct method of bending pipe, and perhaps in many pipe bending situations, the only convenient method. This would particularly be the case if no bending slap were available, or if time considerations did not permit the rather lengthly sand-packing process.

Basically, wrinkle bending consists of a simple heating operation in which a section of the pipe is heated by a gas welding torch. When the metal becomes plastic (bright red color) the pipe is bent SLIGHTLY, either by hand or by means of tackle rigged for that purpose. The heated portion, which stretches, forms the heel (outside) of the bend, while the wrinkle is formed at the throat (inside) of the bend due to compression.

It ought to be understood that the pipe should not be bent through very large angles (12° being considered the maximum for one wrinkle) in order to avoid the danger of the pipe buckling. The procedure in making a large bend is to make several wrinkles, one at a time. If, for example, you want to produce a bend of 90°, a minimum of eight separate wrinkles could be made. Figure 6-19 shows a 90° bend made with 10 separate wrinkles.



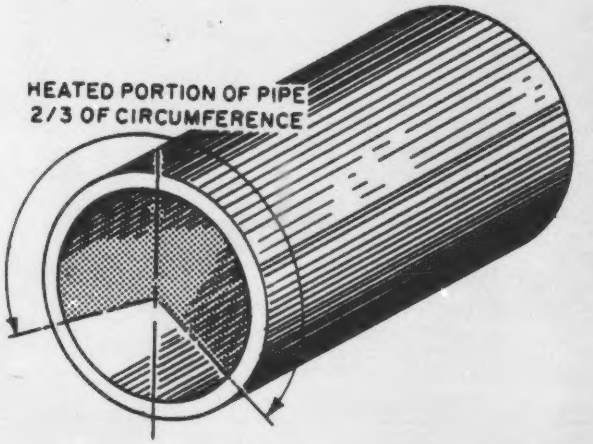
127.149
Figure 6-19.—90° bend made with 10 separate wrinkles.

Wrinkle bending has been sucessful on pipe of more than 20 inches in diameter. Experience has shown that, for six inch diameter pipe and over, more complete and even heating is accomplished using two welding torches rather than one. In any event, the heating procedure is the same, the torch or torches being used to heat a strip approximately two-thirds of the circumference of the pipe (see fig. 6-20). The heated strip need not be very wide (2-3 inches is usually sufficient) since the bend will only be through about 12° at most. The heated portion, as we have noted, is the part which will stretch to become the outside of the bend. The portion which is not heated directly will compress slightly and pucker to form the wrinkle.

The technique most often used to bend the pipe, once it has been heated, is simple and straightforward. The pipe is merely rolled over (heated portion on underside) and one end lifted up by hand (or by tackle), while the other end is held firmly on the ground.

LAYOUT OPERATIONS

Lack of templates, charts, and mathematical formulas need not hinder you in pipe layout. In emergencies, welded pipe of equal diameter can be laid out in the field quickly and easily. By using the methods described here and a few simple tools, you can lay out branches and



127.150
Figure 6-20.—Part of pipe heated prior to wrinkle bending.

Y-connections as well as turns of any angle, radius, and number of segments.

The few simple tools required are both readily available and familiar to the Steelworker through almost daily use. A framing square, a bevel protractor with a 12-inch blade, a spirit level, a spring steel wrap-around (or tape), a center punch, a hammer, and soapstone will meet all needs. (A stiff strip of cardboard or sheet tin about 3 inches wide also makes a good wrap-around.) For purposes of our discussion, the long part of the framing square is referred to as the BLADE and the short part as the TONGUE.

Two methods of pipe layout are commonly used; they are the one-shot method and the ship method. The ONE-SHOT method is used in the field. With this method, you will use handtools and make your layout on the pipe to be cut. As you can easily see, the one-shot method is so named because you only use it once.

In the SHOP METHOD you will make templates for pieces that are going to be duplicated in quantity. As an example, a job order comes into the ship for 25 pieces of 6-inch pipe, all cut at the same degree. Obviously, it would be very time-consuming to use the one-shot method; hence, the shop method is used for laying out. Patterns can be made of template paper or thin-gage sheet metal. An advantage of thin-gage sheet metal templates is that when you have finished with them, they can be stored in an appropriate place in the toolroom for later use.

Bear in mind that all pipe turns are measured by the number of degrees by which they turn aside from the course set by the adjacent straight section. The angle is measured between the centerline of the intersecting sections of pipe. Branch connections are measured in angle of turn away from the main line. For example, a 60-degree branch is so called because the angle between the centerline of the main pipe and the centerline of the branch connection measures 60 degrees. Turns are designated by the number of degrees by which they deviate from a straight line.

QUARTERING THE PIPE

In laying out any joint, the first step is to establish reference points or lines from which additional measurements or markings can be made. This is done by locating a centerline and dividing the outside circumference of the pipe into 90-degree segments or quarters. The framing square, spirit level, and soapstone are used in the following manner.

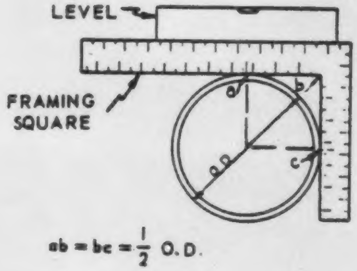
Block the pipe so it cannot move or roll; then place the inside angle of the square against the pipe and level one leg. One point on the centerline is then under the scale at a distance of half the outside diameter of the pipe from the inside angle of the square (see fig. 6-21). Repeating at another part of the pipe will locate two points, and hence the centerline. By this same method the quarter points also may be located. This operation is a must prior to any layout with the field method.

If you are using a long piece of pipe and are going to cut both ends, in addition to the square, you will need a piece of carpenter's chalk-line with a plumb bob on each end and two 24- or 36-inch flat steel rules (depending on the diameter of the pipe) to locate top and bottom centerlines. Figure 6-22 shows a plumb bob and rules being used to locate top and bottom centerlines.

Another one-shot method of quartering pipe is to take a strip of paper and wrap it around the pipe and tear or cut the part that overlaps. The ends should touch. Remove the paper from the pipe and fold it in half, as illustrated in view A, figure 6-23. Then double the strip once again, as shown in view B. This will divide your strip into four equal parts. Place the strip of paper around the pipe. At the crease marks and where the ends meet, mark the pipe with soapstone and your pipe will be quartered.

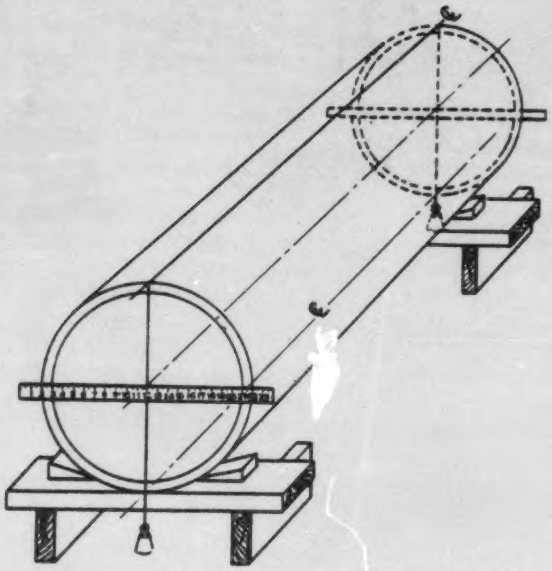
TEMPLATE FOR TWO-PIECE TURN

The fact that a length of pipe with square ends can be fabricated by wrapping a rectangular

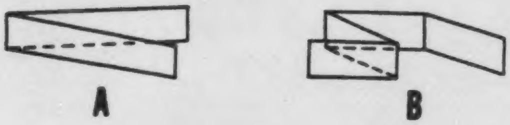


145.186X

Figure 6-21.—Locating top and side quarter points.



145.187X
Figure 6-22.—Locating top and bottom centerlines.



127.151
Figure 6-23.—Folding strip of paper for use in quartering pipe.

section of plate into a cylindrical form makes available a method (known as parrallel forms) of developing pipe surfaces, and hence developing the lines of intersection between pipe walls. Based on this principle, wrap-around templates can be made for marking all manner of pipe fittings for cutting preparatory to welding.

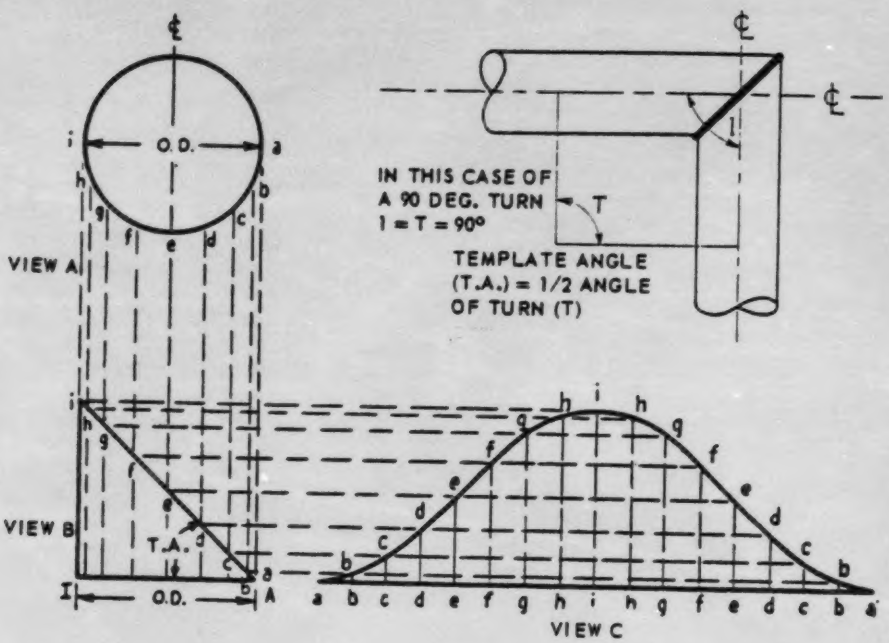
The development of a template is done in practice by dividing the circumference (in the end view) of the pipe into a certain number of equal sections, which are then projected on to the side view of the desired pipe section. The lengths of the various segments which make up the pipe wall may then be laid out, evenly spaced, on a base line which is in effect the unwrapped circumference. This is shown in figure 6-24. If the templet developed in view C, figure 6-24 is wrapped around the pipe with the base line square with the pipe, the curved line a-b-c-d-e-f-etc. will locate the position for cutting to make a 90-degree, two-piece turn. Draw a circle (view A, fig. 6-24) equal to the outside diameter of the pipe and divide half of it into equal sections. The more sections, the more accurate the final result will be. Perpendicular to the centerline, and bisected by it, draw line AI equal to the O.D. (view B, fig. 6-24) and to this line construct the template angle (TA) equal to one-half of the angle of turn, or in this case 45 degrees. Draw lines parallel to the centerline from points a, b, c, etc. on the circle and mark the points where these lines intersect line ai with corresponding letters. As an extension of AI, but a little distance from it, draw a straight line equal to the pipe circumference, or that of the circle in view A figure 6-24. This line (view C, fig. 6-24) should then be divided into twice as many equal spaces as the semicircle a-b-c-etc. and lettered as shown. Perpendiculars should then be erected from these points. Their intersections with lines drawn from the points on ai in view B, figure 6-24 parallel to the base line in view C, figure 6-24 determine the curve of the template.

SIMPLE MITER TURN

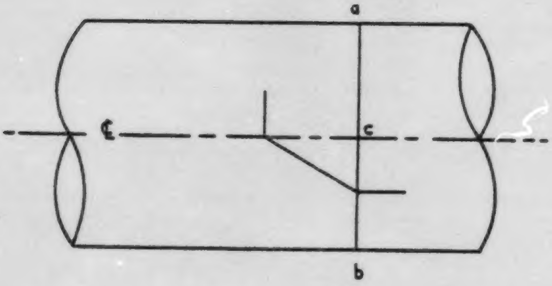
After quartering the pipe, proceed to make a simple miter turn. Locate the center of the cut (see point c in fig. 6-25) in the general location where the cut is to be made. Use a spring steel wrap-around to make line ab completely around the pipe, at right angles to the center and quarter lines, thus establishing a base line for further layout work.

When measuring, treat the surface of the pipe as if it were a flat surface. Use a flat steel rule or tape, which will lie against the surface without kinks, even though it is forced to follow the contour of the pipe. These angles can also be checked for accuracy by sighting with the square.

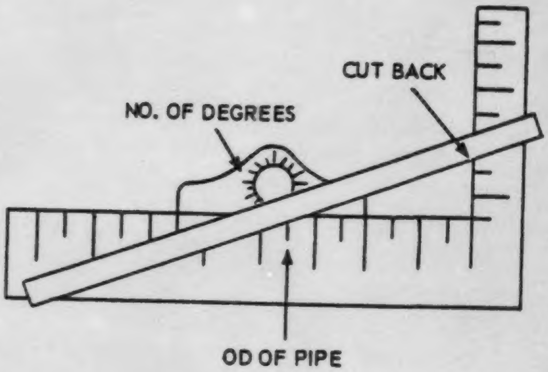
Use the protractor and square to determine the proper amount of cut-back for the desired angle of the miter turn. Start with the protractor scale set at zero, so that the flat surface of the protractor and the blade are parallel. You can now set the protractor for the number of degrees desired. After you have the correct setting, lock the blade. Place the protractor on the square with the bottom blade on the outside diameter of the pipe. Now read up to the


℄
O.D.
i
a
h
b
g
c
f
e
d
VIEW A
IN THIS CASE OF
A 90 DEG. TURN
1 = T = 90°
T
1
TEMPLATE ANGLE
(T.A.) = 1/2 ANGLE
OF TURN (T)
VIEW B
T.A.
I
O.D.
A
a b c d e f g h i h g f e d c b a
VIEW C

145.188X
Figure 6-24.—Principles of template layout.



145.189
Figure 6-25.—Simple miter turn.


CUT BACK
NO. OF DEGREES
OD OF PIPE

145.190
Figure 6-26.—Finding the cut-back.

cut-back on the vertical blade and take one-half. You must be sure that the flat surface of the protractor is flush against the blade of the square (see fig. 6-26). The outside radius of the pipe should have been determined during the quartering operation.

After you have obtained the cut-back measurement, mark one-half off along the centerline on top of the pipe. From the opposite side measure off the same distance along the bottom quarter line. Make punch marks with the center punch on each side of the line, along the side quarter lines. These marks will make it easy to align the pipe for welding after the joint is cut. Use the spring steel wrap-around and pull the loop to the cut-back point; then, draw a chalk line over the top half of the pipe through the first cut-back point. A word of caution is: do not allow the wrap-around to twist or kink, and hold the chalk at a right angle to it while marking the pipe. Now roll the pipe one-half turn and mark a chalk line in the same way around the bottom half of the pipe.

TWO-PIECE TURN

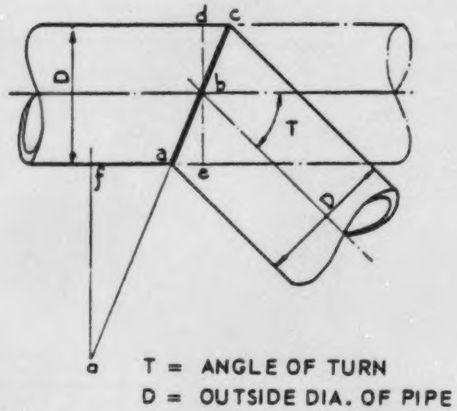
If a template is not available, dimensions and markings for the cut necessary for a two-piece welded turn of any angle between 1 and 90 degrees may be determined by making a full-sized drawing as shown in figure 6-27.

Draw the centerlines intersecting at b by using the angle of turn T and then draw the outlines of the pipes by using the centerlines and the diameter D. These will intersect at a and c. By laying the pipe over the drawing so that point b will coincide with that determined by construction details, the line a-b-c-b may be drawn in preparation for miter cutting and beveling.

After being prepared for welding, one section of pipe should be rotated through 180 degrees to form the desired angle, and then should be tack-welded. Spacing should be slightly greater at the inside of the turn.

WELDED TEE

To layout the template for cutting the branch and header for a 90-degree tee with header and branch of equal diameter, draw the side and end view as shown in figure 6-28, views A and B.



145.191
Figure 6-27. — To locate cut on pipe for any angle two-piece turn.

In making the template for the branch in figure 6-28, view A, draw lines 1 - 5 at 45 degrees to the centerline. Lay off distance 1-P equal to twice the thickness of the pipe wall and draw the smooth curve S-P-S. Now, project point P from view A to view B and draw the lines P-t radially. At a distance above point t equal to the thickness of the header wall, draw a-t horizontally, and vertical lines a-a and t-t. With lower points a as centers and a radius equal to one-half the header O.D., swing arcs m-n; then with e as a center swing arcs r-s. Using the intersections of these arcs as centers, and with the same radius, draw the curved lines a-b-c-d-e and e-d-c-b-a.

Divide the outside circumference of the branch top into equal parts and draw the vertical lines b-b, c-c, etc. Also, draw the horizontal base line a-a.

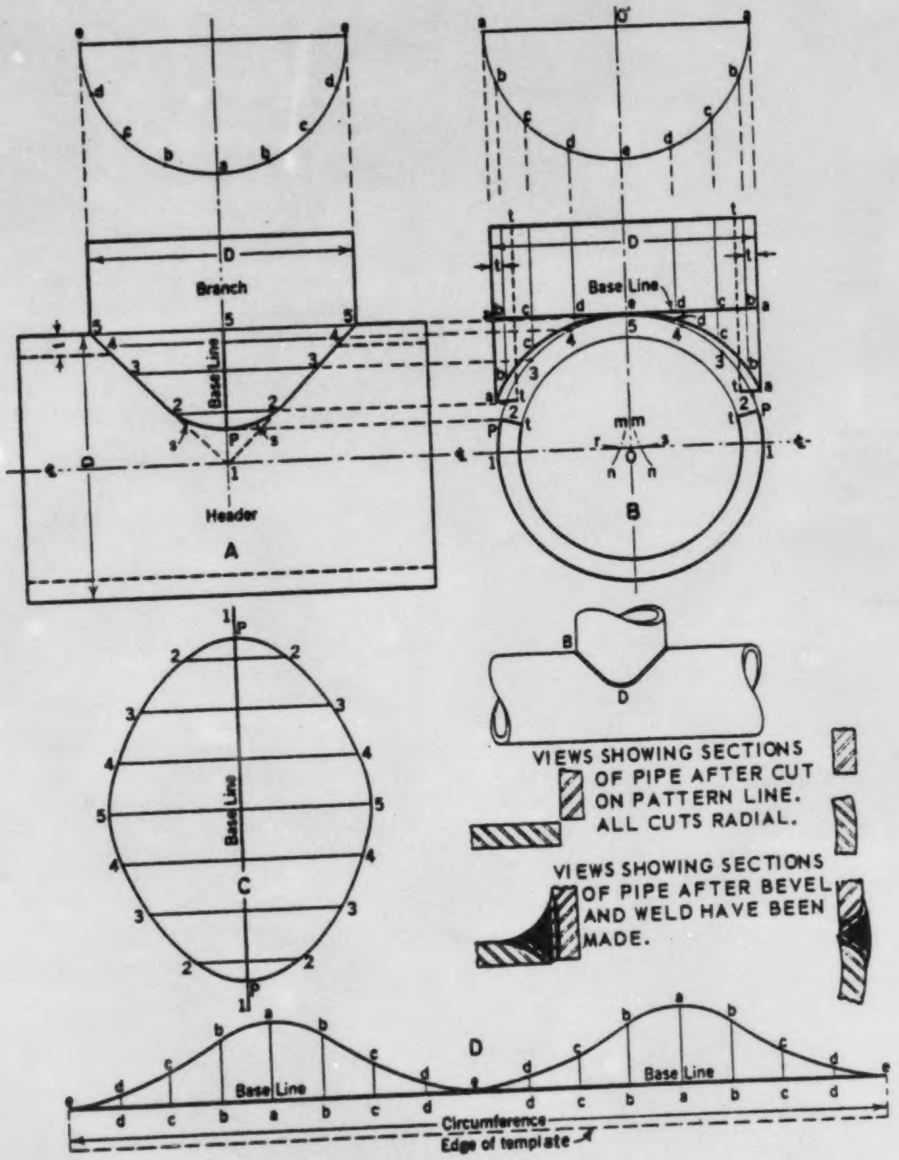
Lay off the unwrapped circumference as shown in view D (fig. 6-28) and divide each half of it into the same number of equal parts as the branch semicircumference. Plotting in view D the distances a-a, b-b, etc., from view B, which give the distances from base line to the branch curve of intersection, determines the location of the branch template.

To make the template for the hole in the header, divide the circumference of the header into equal parts, as at points 1, 2, 3, etc., and project these points across to view A (fig. 6-28) as shown. As in view C, lay off the line 1-5-1 equal to one-half the circumference of the header, and divide it into the same number of equal parts as was done on the header. Locate point P, a distance from 1 in view C equal to 1-P in view B. With this point P and the distances 5-5, 4-4, etc., in view A, plotted as shown in view C, the curve of the template is located.

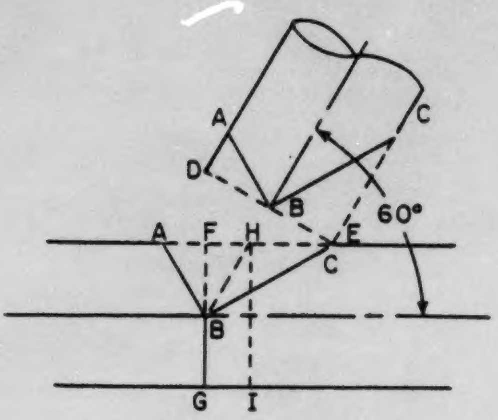
BRANCH CONNECTION

Branch to header connections, as shown in figure 6-29, at any angle of 45 to 90 degrees can be fabricated in equal diameter pipe by the following procedures. (Note that angles less than 45 degrees can be made, but practical limitation is imposed by difficulty of welding the crotch section.)

First quarter both sections of pipe as before. Then locate the centerline of intersection (point B) on the header and draw line GF around the pipe at this point. Set the diameter FG on the blade of the square. Set and lock the protractor at


D
Branch
Base Line
Header
A
B
Base Line
C
Base Line
D
Base Line
Base Line
Circumference
Edge of template
B
D
VIEWS SHOWING SECTIONS OF PIPE AFTER CUT ON PATTERN LINE. ALL CUTS RADIAL.
VIEWS SHOWING SECTIONS OF PIPE AFTER BEVEL AND WELD HAVE BEEN MADE.

145.192X
Figure 6-28.—90° tee.



145.193
Figure 6-29.—Branch connections.

one-fourth the number of degrees of turn away from the header (in the example 1/4 of 60° = 15°). With the blade along FG, the first cut-back measurement, FA, will be indicated on the tongue of the square. Measure off this distance along the centerline of the header from line FG and mark point A. As described before, join point A with the points of intersection of line FG and the two side quarter lines, to outline the first cut.

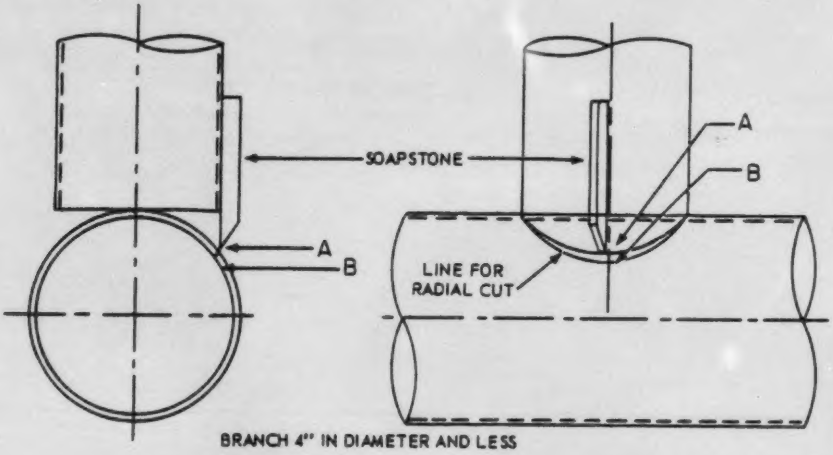
With the same protractor setting, flip the square and mark point H; the distance FH is equal to FA; FH is the first portion of the second cut-back measurement. With the same settings, and with the square upside down as compared with before, locate point I the same was you located point H.

Now, set the protractor to one-half the number of degrees of turn away from the header (in the example 1/2 of 60° = 30°). With the blade set to the diameter, the second portion, HC, of the second cut-back measurement will be indicated on the tongue. The second cut-back measurement is the total distance FC. Connect points C and B and connect C with the point, which corresponds to B, on the quarter line on the opposite side of the header. This outlines the second cut and completes the marking of the header.

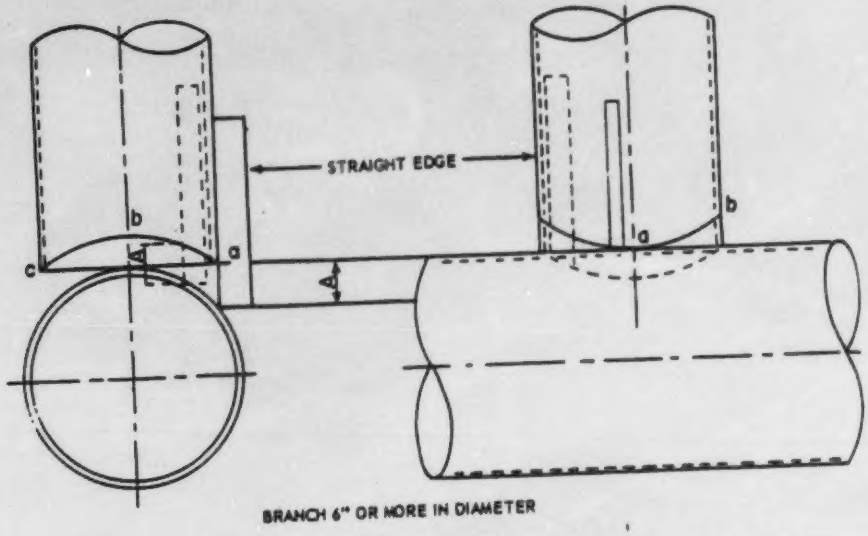
Use the same two cut-back measurements to lay out the end of the branch; branch cut-back distance DA is equal to header cut-back distance FA; branch cut-back distance EC is equal to header cut-back distance FC. If the branch end is square, make cut-back measurements from it rather than marking in a circumferential line. Make all cuts as before, level and join the branch and header by welding.

WELDED TEE (BRANCH SMALLER THAN THE HEADER)

One of the best types of joint for a 90-degree branch connection where the branch is smaller than the header is obtained by inserting the smaller branch pipe through the wall down to the inner surface of the header, so that the outside surface of the branch intersects the inside surface of

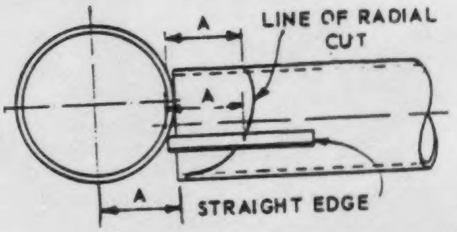


145.194X
Figure 6-30.—Method where line of cut is first marked on main.


STRAIGHT EDGE
b
c
a
A
A
b
a
BRANCH 6" OR MORE IN DIAMETER

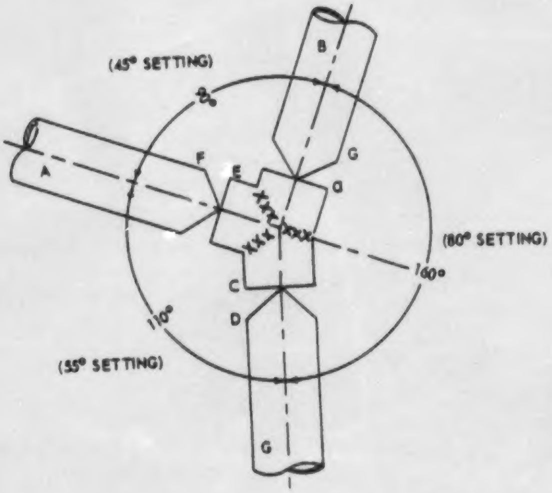
145.195X

Figure 6-31.—Line of cut is first marked on branch with this method.


A
LINE OF RADIAL CUT
A
A
STRAIGHT EDGE

145.196X

Figure 6-32.—Marking cut on branch for eccentric branch connection.


B
(45° SETTING)
A
F
E
G
a
XXX
XXX
XXX
(80° SETTING)
160°
C
D
110°
(55° SETTING)
G

145.197

Figure 6-33.—Three-piece Y connection.

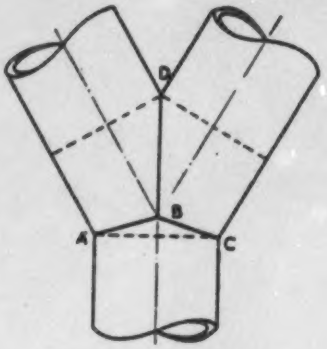
the header at all points. When the header is properly beveled, this type of intersection presents a very desirable vee for welding.

In case templates or template dimensions are not available, the line of cut on both header and branch can be located by other methods, but the use of templates is recommended.

In the first method, the square end of the branch should be placed in the correct position against the header and the line of intersection marked with a flat soapstone pencil, as shown in figure 6-30.

Since radial cutting is employed in this case, and since the outer branch wall should intersect the inner header wall, the point "b" should be located on both sides of the branch a distance from "a" equal to slightly more than the header wall thickness. A new line of cut is then marked as a smooth curve through the points "b", tapering to the first line at the top of the header. Following radial cutting, the joint should then be beveled.

To locate the line of cut on the branch, the branch should be slipped into the hole until even



145.198
Figure 6-34.—True Y.

with point "b". A soapstone pencil may then be used to mark the line for radial cutting. No beveling is necessary.

A second method for larger diameter pipe is shown in figure 6-31. After centerlines have been drawn, the branch should be placed against the header as shown. By means of a straightedge, the distance between "a" and the header wall is determined, and this measurement above the header transferred to the branch wall as represented by the curved line "a-b-c". After this line is radially cut, the branch may be used to locate the line of cut on the header, allowing for the intersection of the outer branch wall and inner header wall as before. This line should be radially cut, followed by beveling.

In making an eccentric branch connection, the extreme case of which is where the side of the branch is even with the side of the header, a similar procedure is followed as shown in figure 6-32.

THREE-PIECE Y CONNECTION

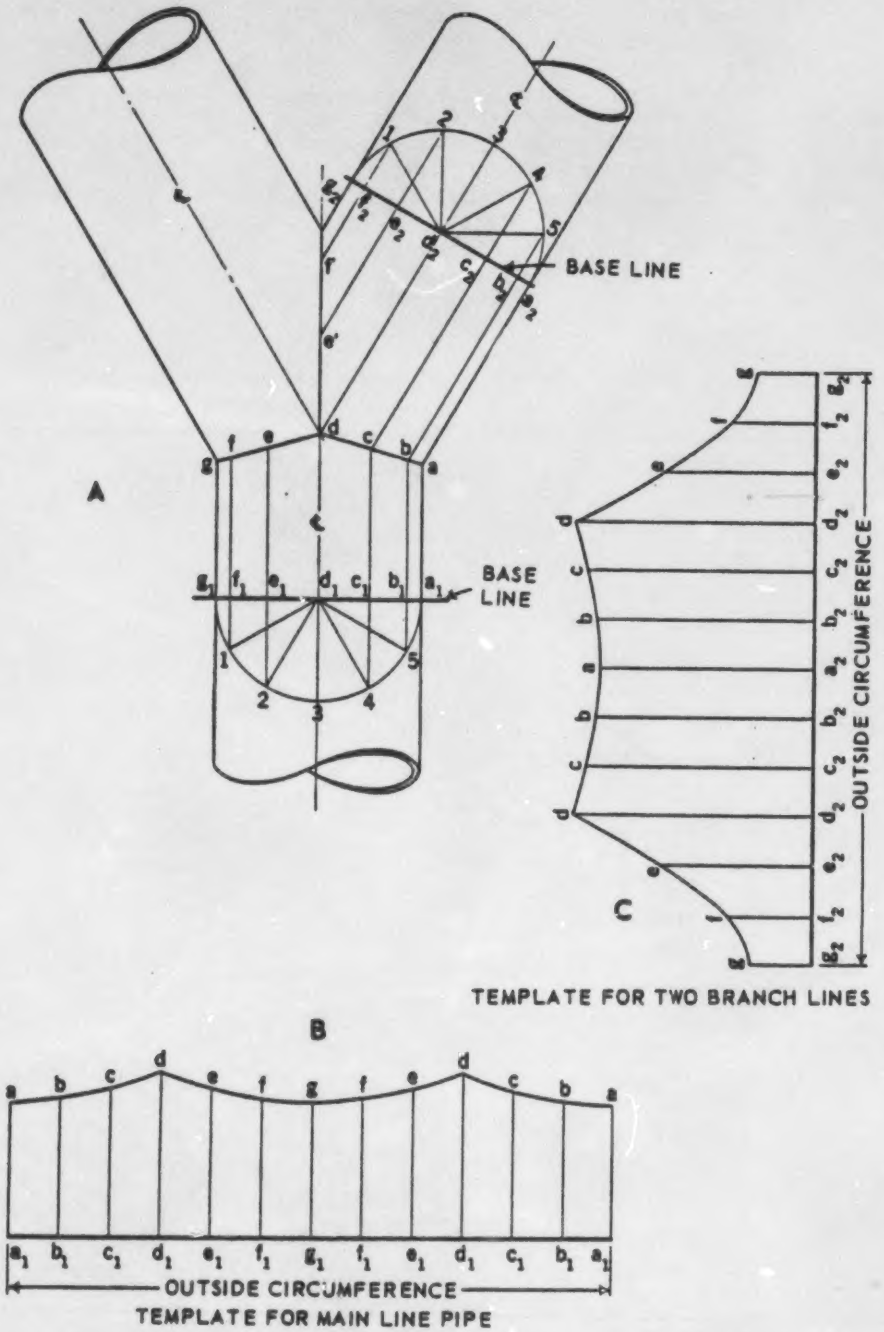
The entire procedure for fabrication of an equal diameter, three-piece Y connection is based on individual operations already described. As the first step, quarter the end of the three pieces of pipe and apply circumferential lines. When the three pieces are welded together to form the Y there will be three centerlines radiating from a common point.

The open angle between each pair of adjacent centerlines must be decided, for each of these angles will be the angle of one of the branches of the Y. As shown in figure 6-33, these open angles determine the angle of adjoining sides of adjacent branches. Thus, half of the number of degrees between centerlines "B" and "G" are included in each of the adjoining cut-backs between these two branches. The same is true with respect to the other angles and cut-backs between centerlines "B" and "A". Moreover, each piece of pipe must have a combination of two angles cut on the end.

To determine the amount of cut-back to form an angle of the "Y", lay the protractor at one-half the open angle between adjacent branch centerlines. Place the protractor on the square, crossing the outside radius measurement of the pipe on the tongue of the square, and read the cut-back distance of the blade of the square. Mark off this distance on one side quarter line on each of the two pieces that are to be joined. Then mark the cut-back lines. Repeat this procedure for the other two angles of the "Y",

127.268
Table 6-2.–Computations and Measurements for a "Y" Connection.

	ACB	ACG	BCG
Open angle between centerlines	90 deg.	110 deg.	160 deg.
Protractor setting (half of each angle)	45 deg.	55 deg.	80 deg.
Cut-backs	6"	4 1/8"	1 1/16"
Centerlines	A	B	G
Paired cut-back measurements (inches)	fe = 6" cd = 4 1/8"	ab = 1 1/16" fe = 6"	ab = 1 1/16" cd = 4 1/8"


A
BASE LINE
BASE LINE
1
2
3
4
5
a b c d e f g
a_1 b_1 c_1 d_1 e_1 f_1 g_1
a_2 b_2 c_2 d_2 e_2 f_2 g_2
e'
C
OUTSIDE CIRCUMFERENCE
TEMPLATE FOR TWO BRANCH LINES
B
a b c d e f g f e d c b a
a_1 b_1 c_1 d_1 e_1 f_1 g_1 f_1 e_1 d_1 c_1 b_1 a_1
OUTSIDE CIRCUMFERENCE
TEMPLATE FOR MAIN LINE PIPE

145.199X
Figure 6-35.—Template for true Y—branches and main of equal diameter.

taking care to combine the cut-backs on each pipe end. Three settings of the protractor determine all cut-backs.

An alternate method for determining each cut-back is to treat two adjacent branches as a simple miter turn. Subtract the number of degrees of open angle between centerlines from 180 degrees and set the protractor at one-half; cross the outside radius measurement on the tongue. Mark one side of each adjoining pipe section. Repeat for the other two branches. Take care to combine the proper cut-backs on each pipe end. Set the protractor for each open angle of the "Y" connection.

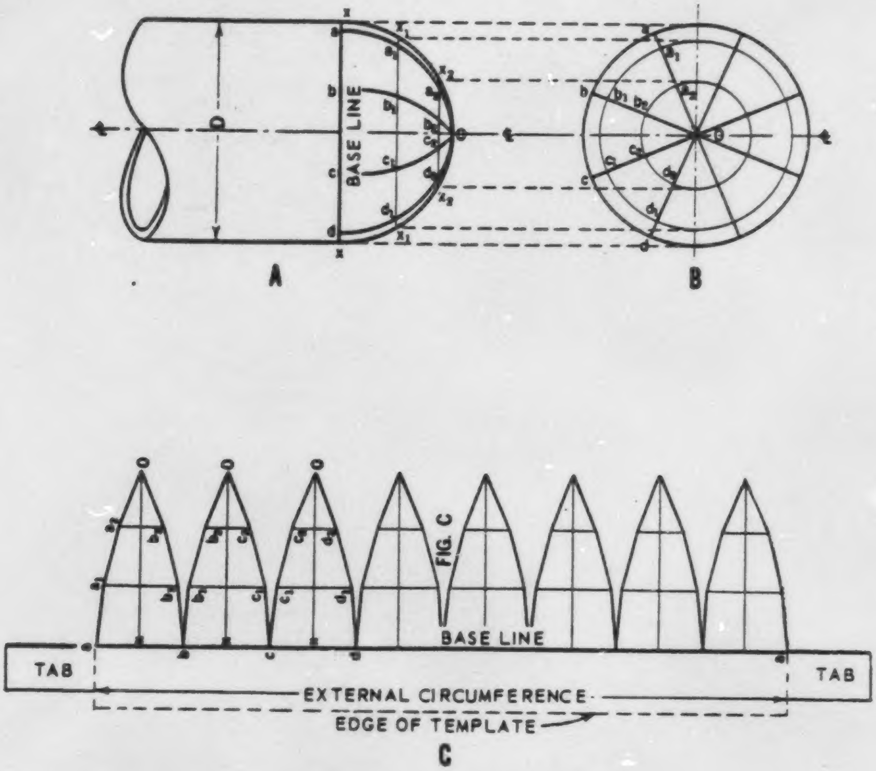
The computations and measurements for the layout shown in figure 6-33 are shown in table 6-2. The pipe is 12-inches in diameter, and as a radius of 6 inches.

LAYOUT OF TRUE Y

In laying out pipe for the fabrication of a true Y without the use of templates or tables, a full-sized drawing of the intersection as shown in figure 6-34 should be made. The intersection of the centerlines of the three pipes will locate point "b", and lines from "b" to the intersections of the pipe walls will locate points a, c, and d. From these points the pipe may be marked for cutting. Miter cutting, followed by suitable beveling, is necessary in preparing the pipe for welding.

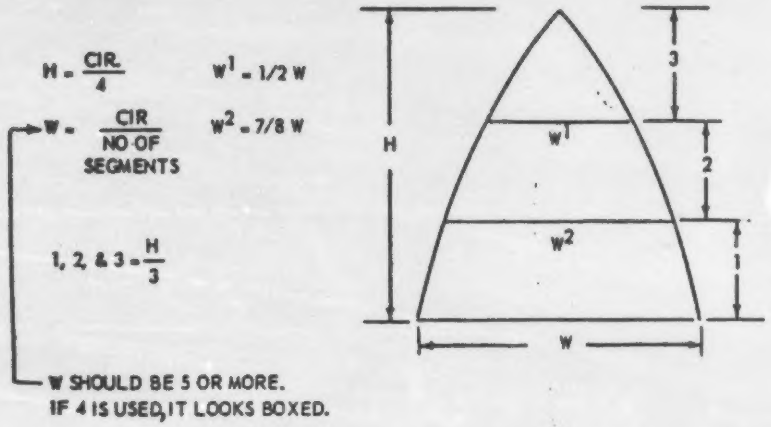
TEMPLATE LAYOUT FOR TRUE Y—BRANCHES AND MAIN LINES

In laying out a template for a true Y, a drawing of the intersection should be made, as shown in view A, figure 6-35. After drawing the lines of intersection, the same essential methods as for other templates are followed. Note that here it is suggested the equally divided semicircumferences are more conveniently placed directly on the base line. The distances from the base line to the line of intersection



145.200X

Figure 6-36.—Orange peel head.



11.201

Figure 6-37.—A field method of making an orange peel.

plotted on the unwrapped base line determine the template.

ORANGE PEEL HEAD

A number of different types of heads are used in welded piping construction. Here, we are interested in one general type, the ORANGE PEEL, since it will often concern you in your work. A main advantage of the orange peel is that it has high strength in resisting internal pressure.

If templates or tables are not available for making an orange peel head, a reasonably accurate marking can be secured by the following procedure for laying out a template.

The number of arms to make an orange peel head should be the minimum number which can be bent over easily to form the head. While five arms and welds are recommended as the minimum number for any pipe, this number should be increased for larger sizes of pipe. Dividing the circumference by five is a good method for deciding the number of arms, provided, of course, there are at least five.

To lay out the template, draw the side and end views as shown in figure 6-36. Divide the pipe circumference in view B into the same number of equal parts as it is planned to have welds, and draw the radial lines o-a, o-b, etc. Project the points a, b, etc., on the base line x-x in view A and draw the lines a-o, b-o, etc., in this view.

Now divide x-o-x into equal parts—in this case, six. Then draw the lines x_1-x_1 and x_2-x_2. These represent the concentric circles in view B. In laying out the template, the distances a-b, b-c, a_1-b_1, a_2-b_2, etc., are taken from view B, while the distances x-o, x-x_1, x-x_2, b-b_1, etc., are taken from view A. (It is not actually necessary to draw views A and B since all the values can be determined by simple computation.) All cutting should be radial followed by a beveling cut.

A one-shot field method of making an orange peel is shown in figure 6-37. This method can be used when you are going to make only one orange peel. Incidentally, the tabs shown in figure 6-37 will help to line up your template better.

SAFETY

The primary safety concern in plate and pipe fabricating operations has to do with the use of cutting and welding torches and related equipment. Specific safety precautions appropriate to the operations covered in this chapter will, therefore, be discussed in the forthcoming chapters on cutting and welding equipment and techniques.

3-24
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CHAPTER 13

SOLDERING

Soldering is a process which joins metals by melting nonferrous filler alloys (commonly known as solders) on the surfaces to be joined. True solders, called SOFT SOLDERS, always have melting points below 800° F, and below the melting points of the metals to be joined. Since the temperatures used for soft soldering are always below 800° F, and the temperatures used for welding are always above 800° F, soft soldering is not classified as a welding process. Soldering is, nevertheless, a valuable adjunct to welding because it is a simple and fast means of joining metals. Although soldered joints are not as strong as welded joints (and, thus, cannot be used where any great mechanical strength is required), soldering is a particulatly useful and effective means of securing electrical connections, joining sheet metal, and sealing seams against leakage. Soldering can be used to join iron, nickel, lead, tin, copper, zinc, aluminum, and many alloys.

This chapter describes the implements and materials required for soft soldering, the three basic methods employed to make soldered joints and, in addition, the special techniques required to solder aluminum alloys.

SOLDERING EQUIPMENT

Soldering requires relatively little equipment. For most soldering jobs, you will need only a source of heat, soldering coppers, solder, and a flux.

SOURCES OF HEAT

The sources of heat used for soldering vary according to the method used and the equipment available. Welding torches, blowtorches, forges, gas ovens or furnaces, and other heating devices may be used. Most commonly, the heating devices are used to heat soldering coppers which then supply the heat required to heat the surfaces and thus melt the solder. However, the heating devices are sometimes used for the direct heating of the surfaces to be joined; in this case, the solder is melted by the heat from the heated surfaces.

If you use a welding torch as a source of heat for soldering, use it carefully. A welding torch gives out much more heat than is actually required for soldering. If you overheat the soldering coppers, you will have to retin them and perhaps reforge them. Excessive heat may also damage the metal that is being joined and may cause deterioration of the solder.

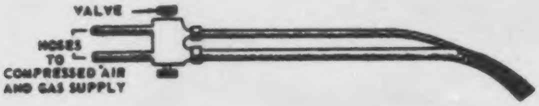
A gas blowpipe of the type shown in figure 13-1 is often used to supply the heat required for soldering. It may be used either to heat the soldering coppers or to heat the surfaces to be joined.

An alcohol torch is shown in figure 13-2. This torch is a self-contained unit which requires no outside source of pressure. The alcohol tank is filled about two-thirds full of alcohol and then sealed. To operate the torch, remove the cap and light the wick. The flame from the wick heats the jet tube, causing the liquid alcohol in the container to vaporize and expand. The expansion of the alcohol forces the alcohol vapor from the jet opening, where it burns with a hot flame.

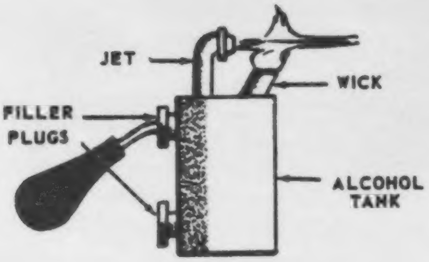
If a gas oven or furnace is available, you will find that this is the best device for heating soldering coppers. One type of gas oven that may be used for heating soldering coppers is shown in figure 13-3.

SOLDERING COPPERS

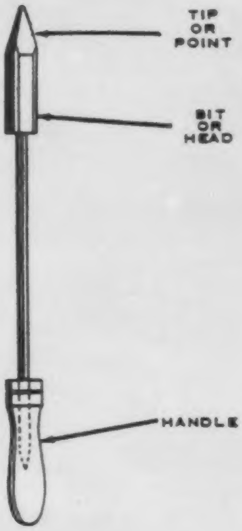
A soldering copper (sometimes called a soldering iron) consists of a forged copper head, a handle, and an iron rod which connects the head and the handle. (See fig. 13-4.) The handles may be made of wood or of fiber. Handles are sometimes forced on the rod and sometimes screwed on.


VALVE
HOSES TO COMPRESSED AIR AND GAS SUPPLY

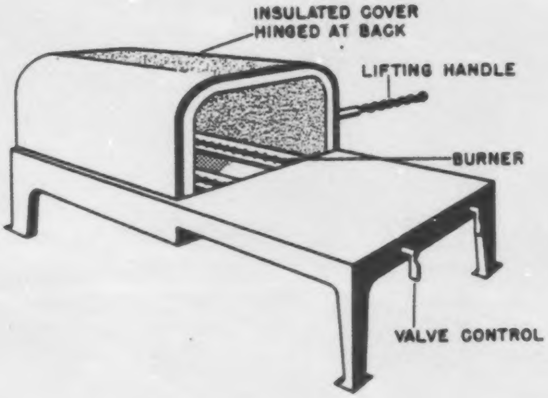
11.142
Figure 13-1.—Gas blowpipe.


JET
WICK
FILLER
PLUGS
ALCOHOL TANK

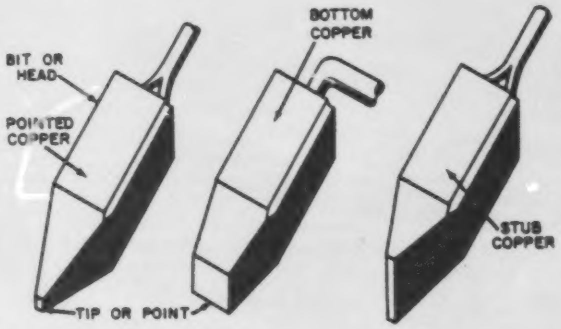
11.143
Figure 13-2.—Alcohol torch.


TIP OR POINT
BIT OR HEAD
HANDLE

11.145
Figure 13-4.—Soldering copper.


INSULATED COVER HINGED AT BACK
LIFTING HANDLE
BURNER
VALVE CONTROL

11.144
Figure 13-3.—Gas oven.

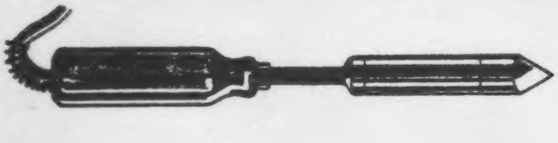

BIT OR HEAD
POINTED COPPER
BOTTOM COPPER
STUB COPPER
TIP OR POINT

11.146
Figure 13-5.—Soldering copper heads.

Heads are available in various shapes. Figure 13-5 shows some of the most commonly used types of heads. The bottom copper is used for soldering seams in pails, pans, trays, and other objects in which the seams are hard to reach. The stub copper is used for soldering flat seams where a considerable amount of heat is required. The pointed copper is used for general soldering work.

Electric soldering coppers (fig. 13-6) are built with internal heating coils. The heads are removable and interchangeable.

Coppers that are not electrically heated are supplied in pairs so that one copper may be used while the other is being heated. The size designation of coppers refers to the weight (in pounds) of TWO copper heads. Thus a reference to a pair of 4-pound coppers indicates that each copper



1.26A
Figure 13-6.— Electric soldering copper.

head weighs 2 pounds. Pairs of coppers are commonly supplied in 1-pound, 1-1/2-pound, 3-pound, 4-pound, and 6-pound sizes.

Heavy coppers should be used for soldering heavy gage metals, and light coppers should be used on thinner metals. A light copper will not hold enough heat to heat heavy metals properly, and a heavy copper is likely to overheat thin metals.

Filing and Tinning Coppers

New soldering coppers must be tinned (coated with solder) before they are used. Also, coppers must be filed and retinned whenever they have been overheated or have for any reason lost their coating of solder. The procedure for filing and tinning a copper is as follows:

1. Heat the copper to a cherry red.

2. Clamp the copper in a vise, as shown in figure 13-7.

3. File the copper with a single-cut bastard file. Bear down on the forward stroke and release pressure on the return stroke. Do not rock the file. Continue filing the tapered sides of the copper until they are bright and smooth. CAUTION: Remember that the copper is hot! Do not touch it with your bare hands.

4. Smooth off the point of the copper and smooth off any sharp edges.

5. Reheat the copper so that it will be hot enough to melt the solder.

6. Rub each filed side of the copper back and forth across a cake of sal ammoniac, as shown in figure 13-8.

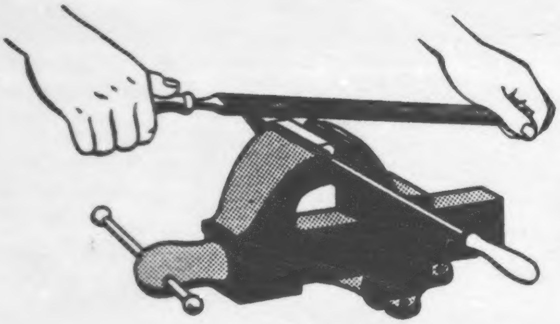
7. Apply solder to the copper until it is tinned. The solder may be rubbed directly on the copper or it may be placed on the cake of sal ammoniac. Do not push the iron into the cake of sal ammoniac. This can split the cake.

If sal ammoniac is not available, powdered rosin may be used instead. In this instance, the powdered rosin may be placed on top of a brick. (See fig. 13-9.) The copper is rubbed back and forth to pick up the rosin. The solder can then be placed directly on the copper.

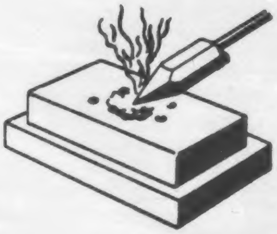
Commercially prepared soldering salts may also be used in tinning soldering coppers. These salts are available in powder form; dissolve the powder in water to make a solution, following the directions which accompany the material. Dip the soldering copper into the solution, and then apply the solder.

Forging Soldering Coppers

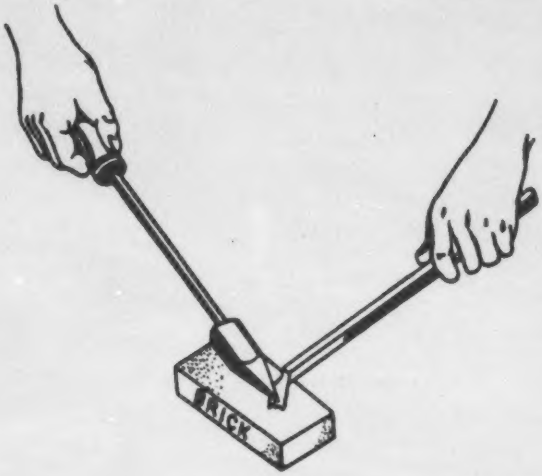
Soldering coppers may be reshaped by forging when they have become blunt or otherwise



11.147X
Figure 13-7.— Filing a soldering copper.



11.148X
Figure 13-8.— Tinning a copper (solder placed on cake of sal ammoniac).



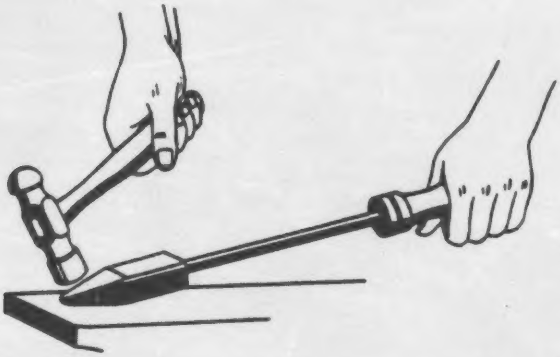
11.149X
Figure 13-9.—Tinning a copper (solder placed directly on copper).

deformed. The procedure for forging a copper is as follows:

1. File the copper to remove all old tinning and to smooth the surfaces.

2. Heat the copper to a bright red.

3. Hold the copper on an anvil and forge it to the required shape by striking it with a hammer, as shown in figure 13-10. Keep a blunt point on the copper by hammering the point back as the forging progresses; this is necessary because the copper would cool off too rapidly if the point is too sharp. Turn the copper often to produce the necessary squared-off sides. Reheat the copper as often as necessary during this part of the forging.



11.150X
Figure 13-10.—Forging a soldering copper.

4. Reheat the copper to a bright red and use a flat-faced hammer to remove as many hollows as possible.

5. File and tin the copper by the procedure previously described.

Dipping Solutions

The soldering copper must be kept clean and bright while soldering. This can be done by dipping the hot soldering copper into a dipping solution just before soldering. The dipping solution removes the oxide from the point, leaving a clean and bright point. A dipping solution is made by dissolving about 1/8 ounce of powdered sal ammoniac in one pint of water. A solution made by dissolving soldering salts in water may also be used as a dipping solution. The acid or flux should not be used as a dipping solution. The heat from the copper will change the color of the flux which will in turn stain the work.

SOLDERS

Most soft solders are alloys of tin and lead. Occasionally antimony, silver, arsenic, or bismuth are added to give special properties to the solders. Solders used for joining aluminum are usually alloys of tin and zinc or of tin and cadmium. As mentioned before, soft solders have melting points below 800° F and below the melting points of the metals being joined. The melting points of most tin-lead solders range from about 360° F to about 465° F.

Tin-lead solders are usually identified by numbers which indicate the percentage of tin and the percentage of lead. The first number gives the percentage of tin, the second gives the percentage of lead. For example, a 30/70 solder is an alloy of 30 percent tin and 70 percent lead. A 50/50 solder (sometimes called half-and-half solder) is an alloy of 50 percent tin and 50 percent lead. A 15/85 solder is an alloy of 15 percent tin and 85 percent lead. Solders containing a high percentage of tin are more expensive than those containing a high percentage of lead. In general, the solders which contain a high percentage of tin have lower melting points than those which contain a high percentage of lead.

Solders are available in various forms, including bars, wires, ingots, and powders. Wire solder is available with or without a flux core.

FLUXES

To make a satisfactory joint, both the metal to be joined and the solder must be free of dirt, grease, oxides, and other foreign matter which would keep the solder from adhering to the metal. Fluxes are used to clean the joint area, to remove the oxide film which is normally present on any metal, and to prevent further oxidation. Fluxes also decrease the surface tension of the solder and thus make the solder a better wetting agent. Table 13-1 shows the fluxes that are generally used with some common metals.

Fluxes are generally classified as corrosive, mildly corrosive, and noncorrosive.

CORROSIVE FLUXES have the most effective cleaning action. However, any trace of corrosive flux that remains on the work will cause subsequent corrosion of the metal. Therefore, corrosive fluxes are not used for soldering electrical connections and for other work in which subsequent corrosion would present a serious problem.

The most commonly used corrosive fluxes are sal ammoniac (ammonium chloride) and zinc chloride. These fluxes are frequently used in solution or in paste form. The solvent is evaporated as the work is heated, leaving a layer of solid flux on the work. At the soldering temperature, this layer of flux melts and partially decomposes, liberating hydrochloric acid. The hydrochloric acid dissolves the oxides from the surface of the work and from the solder.

Zinc chloride (sometimes called CUT ACID or KILLED ACID) should be made up in small amounts, as required for use. To prepare zinc chloride, pour a small amount of muriatic acid (the commercial form of hydrochloric acid) into a container. Then add pieces of zinc to the muriatic acid until the liquid no longer boils and bubbles when the zinc is added. The zinc and the acid enter into a chemical reaction which produces zinc chloride and hydrogen gas. When the liquid no longer boils and bubbles, the reaction is complete and the liquid in the container is no longer muriatic acid; instead, it is now a solution of zinc chloride in water.

11.388

Table 13-1.—Fluxes used for soldering Some Common Metals.

Metals	Fluxes
Brass, copper, tin	Rosin
Lead	Tallow, rosin
Iron, steel	Borax sal ammoniac
Stainless steel and other nickel alloys	Phosphenic acid
Galvanized iron	Zinc chloride
Zinc	Zinc chloride
Aluminum	Stearine, special flux

Strain the zinc chloride solution before using it as a flux. Any solution which is not used immediately should be stored in a tightly sealed glass container.

Certain precautions must be observed in preparing zinc chloride. Do not inhale the fumes given off by muriatic acid or by the mixture of muriatic acid and zinc; these fumes are injurious to personnel and corrosive to metals. Do not prepare zinc chloride in a closed space. Hydrogen gas is liberated as the zinc reacts chemically with the muriatic acid. HYDROGEN IS VIOLENTLY EXPLOSIVE! Zinc chloride should always be prepared out in the open or very near openings to the outside, to minimize the danger of explosion. Also, precautions should be taken to prevent flames or sparks from coming in contact with the liberated hydrogen.

Another type of corrosive flux that you may use is known as SOLDERING SALTS. Commercially prepared soldering salts are usually furnished in powder form; the powder is dissolved in water to make a solution.

When a corrosive flux has been used for soldering, the flux residue should be removed from the work as completely as possible. Most corrosive fluxes are soluble in water; washing the work with soap and water and then rinsing thoroughly with clear water usually removes the residue of corrosive fluxes. This cleaning should be done immediately after the soldering has been completed.

MILDLY CORROSIVE FLUXES such as citric acid in water are sometimes used for soldering. These fluxes have some advantages of the more strongly corrosive fluxes and some advantages of the noncorrosive fluxes. The mildly corrosive fluxes clean the surfaces of the work but do not leave a strongly corrosive residue. Mildly corrosive fluxes are generally used for soldering parts which can be rinsed with water after they have been soldered, or for work in which a mildly corrosive residue can be tolerated.

NONCORROSIVE FLUXES are used for soldering electrical connections and for other work which must be completely protected from any trace of corrosive residue. Rosin is the most commonly used noncorrosive flux. In the solid state, rosin is inactive and noncorrosive. When it is heated, it becomes sufficiently active to reduce the oxides on the hot metal and thus perform the fluxing action. Rosin may be obtained in the form of powder, paste, or liquid.

Rosin fluxes frequently leave a brown stain on the soldered metal. This stain is difficult to remove, but it can be prevented to some extent by adding a small amount of turpentine to the rosin. Glycerine is sometimes added to the rosin to make the flux more effective.

METHODS OF SOLDERING

The three soldering methods that you are most likely to use are (1) soldering with coppers, (2) torch soldering, and (3) soldering by sweating.

The following general considerations apply to most methods of soldering:

1. Be sure that all surfaces to be soldered are clean and free of oxide, dirt, grease, or other foreign matter.

2. Use a flux which is appropriate for the particular job. Some work requires the use of corrosive fluxes, while other work requires the use of noncorrosive fluxes. Remember that the melting point of the flux must be BELOW the melting point of the particular type of solder you are going to use.

3. Heat the surfaces just enough to melt the solder. Solder will not stick to unheated surfaces. However, you should be very careful not to overheat solder, soldering coppers, or surfaces to be joined. In general, solder should not be heated much above the working temperature. As the temperature of molten solder is increased, the rate of oxidation is increased. When molten solder is overheated in air, more tin than lead is lost by oxidation. Any scum formed by oxidation must be skimmed off and discarded. This skimming process changes the proportions of tin and lead remaining in the rest of the solder, since tin and lead oxidize at different rates. When solder must be melted and then carried some distance to the work, it is necessary to heat the solder to a temperature slightly higher than the working temperature. If solder is heated in this manner, protect the surface from oxidation by covering it with a protective mixture of powdered borax, charcoal, and soda.

4. After making a soldered joint, remove as much of the corrosive flux as possible. Ideally, all of the corrosive flux should be removed. In practice, however, it may not be possible to remove all traces of the flux.

SOLDERING WITH COPPERS

For soldering with coppers that are not electrically heated, follow this procedure:

1. Select soldering coppers of the proper size and shape for the work to be done. File and tin the coppers if necessary.

2. Heat one copper. (The other copper should be heated while you are using the first one for soldering.)

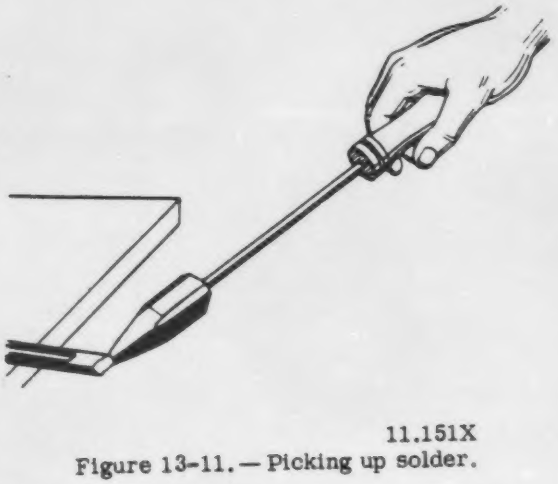
3. Position the work on a suitable support.

4. Apply the flux with one or two strokes of a brush or a swab.

5. Clean the hot soldering copper with sal ammoniac, as described earlier in this chapter.

6. Touch the solder with the hot copper so that a small amount of solder flows over the tip of the copper, as shown in figure 13-11.

7. If the seam to be soldered is not already tacked, grooved, riveted, or otherwise held together, tack the pieces together so that the work



11.151X

Figure 13-11.—Picking up solder.

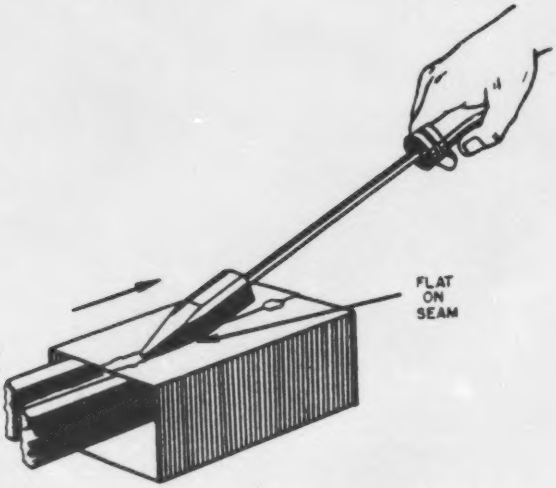
will stay in position while you are soldering it. The piece should be positioned so that the seam itself does not rest directly on the support. This is necessary in order to prevent loss of heat to the support (see fig. 13-12).

8. After the pieces have been firmly fastened together, solder the seam. Heat the spot by holding the copper against the work. The metal to be soldered must absorb enough heat from the copper to melt the solder, or the solder will not adhere. Hold the copper so that one tapered side of the head is flat against the seam, as shown in figure 13-12. When the solder begins to flow freely into the seam, draw the copper along the seam with a slow, steady motion. Add as much solder as necessary, without raising the copper from the work.

9. When the copper becomes too cool, use the other copper and reheat the first one. Change coppers as often as necessary. Remember, however, that the best soldered seams are made by soldering without lifting the copper from the work and without retracing completed work.

10. Allow the joint to cool and the solder to set before moving the joint.

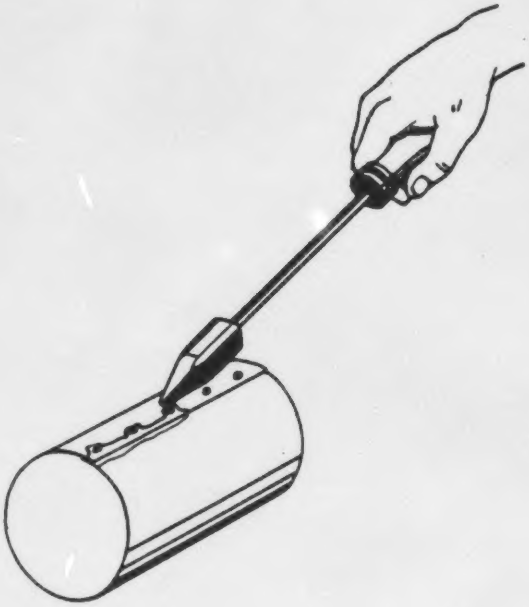
11. If you used a corrosive flux, clean the joint by rinsing it with water and then brushing or wiping it with a clean, damp cloth.



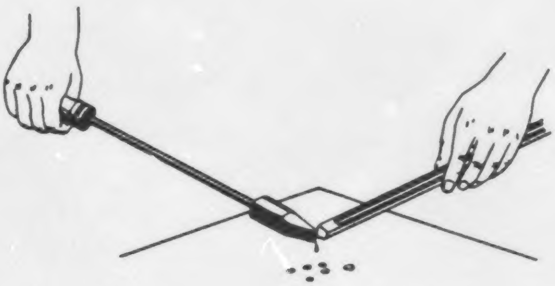
1.152
Figure 13-12.—Soldering a seam.

Riveted seams are often soldered to make them watertight. Figure 13-13 shows the procedure for soldering a riveted seam.

Solder beads or solder shots are sometimes used for soldering square, rectangular, or cylindrical bottoms. To make the solder beads, hold solder against a hot copper and allow the beads to drop onto a clean surface, as shown in figure 13-14.



11.153X
Figure 13-13.—Soldering a riveted seam.



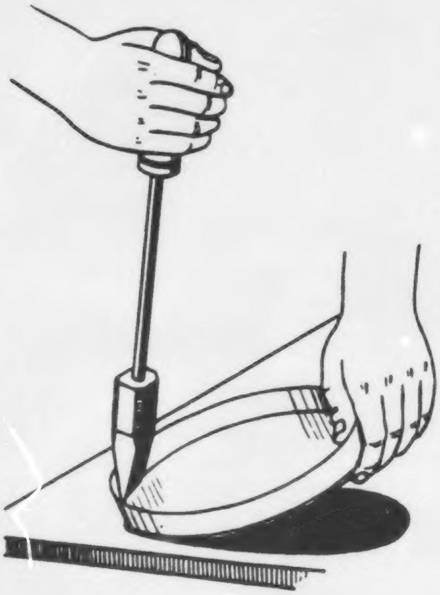
11.154X
Figure 13-14.—Making solder beads.

To solder the bottom seam with solder beads, first flux the seam. Then drop one of the cold beads of solder in the bottom of the container. Heat, clean, and dip the soldering copper and place it against the seam, as shown in figure 13-15. Hold the soldering copper in one position until the solder starts to flow freely into the seam. Draw the copper slowly along the seam, turning the work as you go. Add more beads as you need them. Reheat the copper as necessary.

To heat an electric soldering copper, you merely plug it in. Otherwise, the procedure for using electric soldering coppers is much the same as that just described. Be very careful not to overheat an electric soldering copper. Never go off leaving an electric soldering copper plugged in. Overheating is likely to burn out the electrical element as well as damage the tinning.

TORCH SOLDERING

Torch soldering is often used for small jobs or for work which is relatively hard to reach. A gasoline blowtorch, a gas blowpipe, an alcohol torch, or some other type of torch may be used for torch soldering.



11.155X
Figure 13-15.—Soldering a bottom seam.

The general procedure for torch soldering is to play the flames from the torch onto the surfaces to be joined and then apply cold solder in bar or wire form. The heated surfaces melt the solder. As the solder melts, any excess solder should be wiped off with a damp cloth before it has time to become completely hard.

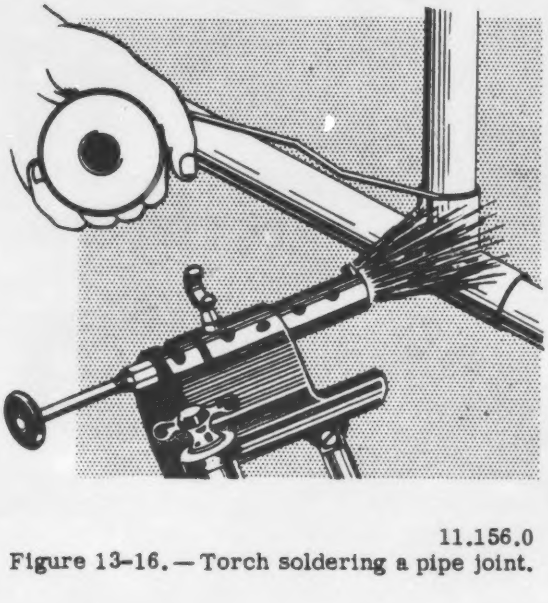
Soldered joints in low pressure, low temperature piping systems are sometimes made up by the torch soldering method. Figure 13-16 shows a pipe joint being torch soldered. If you must solder a joint near a previously soldered joint, wrap the previously soldered joint with a cool wet rag to keep the solder from melting.

SOLDERING BY SWEATING

The sweating method of soldering is commonly used for making electrical connections. To make a sweated joint, clean and flux each surface to be joined; then tin each surface. Hold the pieces firmly together and heat the joint with a soldering copper or with a torch until the solder melts and begins to run out. Remove the source of heat and hold the parts firmly in position until the solder has completely hardened.

SOLDERING ALUMINUM ALLOYS

Soldering aluminum alloys is more difficult than soldering many other metals. The difficulty



11.156.0
Figure 13-16.—Torch soldering a pipe joint.

arises largely from the fact that aluminum alloys are always covered with a layer of oxide, the thickness of the layer depending on the type of alloy and the conditions to which it has been exposed.

Many aluminum alloys can be successfully soldered, however, if the proper techniques are used. Wrought aluminum alloys are usually—although not always—easier to solder than cast aluminum alloys. Heat treated aluminum alloys are extremely difficult to solder, as are aluminum alloys containing more than 1 percent magnesium.

The solders used for soldering aluminum alloys are generally tin-zinc or tin-cadmium alloys; they are usually referred to as ALUMINUM SOLDERS. Most of these solders have higher melting points than the tin-lead solders used for ordinary soldering. Both corrosive and noncorrosive fluxes are used for soldering aluminum.

The first step in soldering aluminum is to clean the surfaces completely and remove the layer of oxide. If a thick layer of oxide is present, remove the main part of it mechanically by filing, scraping, sanding, or wirebrushing. A thin layer of oxide can often be removed by using a corrosive flux; the flux, of course, must be completely removed from the joint after the soldering is finished.

After cleaning and fluxing the surfaces, tin the surfaces with aluminum solder. Apply flux to the work surfaces and to the solder. You can tin the surfaces with a soldering copper or with a torch. If you use a torch, do not apply heat directly to the work surfaces, to the solder, or to the flux. Instead, play the torch on a nearby part of the work and let the heat be conducted through the metal to the work area. Do not use any more heat than is necessary to melt the solder and tin the surfaces. Work the aluminum solder well into the surfaces. After the surfaces have been tinned, the parts may be sweated together.

A procedure that is sometimes used for soldering aluminum alloys is to tin the surfaces with an aluminum solder and then to use a regular tin-lead solder to actually join the tinned surfaces. This procedure may be used when the shape of the parts prevents the use of the sweating method or when a large amount of solder is required to joint the parts. When using tin-lead solder with aluminum solder, it is not necessary to use a flux.

Another method of soldering aluminum is by "friction soldering." In this method, a molten pool of solder is deposited on the aluminum. The surface of the aluminum underneath the molten pool is scratched so that the oxide coating is abraded and broken up. The oxide floats to the surface of the solder puddle. The solder then tins the bare aluminum surface from which the oxide has been removed. After such tinning, two aluminum surfaces can easily be joined by applying heat to melt additional solder on the tinned area to form a fillet or to fill the joint.

Although mill files, soldering rods, soldering copper points, and other tools or devices may be used to abrade the oxide film and remove it from the surface of the aluminum, the best device for this purpose is a glass fiberbrush. The brush is very easy to use and is more effective than other tools in breaking up the oxide film. When a glass fiber brush is used, the friction soldering process produces better soldered joints than are produced by any other aluminum soldering process. A stainless steel wire brush can also be used to clean the oxides from aluminum.

SOLDERING SAFETY

Soldering operations should not be undertaken by the Steelworker unless he has a knowledge of the nature of the fluxes and solders he will be using. If questions arise regarding the use of a flux or solder, the recommendations of the manufacturer often can be used as a guide.

Fluxes, in particular, must be handled carefully. It is also important that the fumes from fluxes be carried away from operating personnel by suitable ventilation equipment. Some fluxes give off poisonous fumes when heated. And some fluxes—such as hydrazine-based fluxes—can cause serious skin irritation. Bear in mind that many fluxes are either toxic (such as organic chlorides) or flammable (such as alcohol). Common acid fluxes will corrode the skin as well as equipment. If any skin is exposed to flux contact, make sure you wash the affected area thoroughly and immediately. You will find that gloves often are helpful during soldering operations.

Each of the soldering processes involves the use of different equipment. Be sure this equipment is kept in proper operating condition. In view of the safety of the operators of this equipment, the handles of soldering irons should provide adequate insulation from the heat. Also, the electrical connections to the soldering irons should be grounded.

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CHAPTER 18

REINFORCING STEEL

As a Steelworker, you must be able to bend, place, and tie the reinforcing steel which is utilized by Builders to strengthen the concrete structures they erect. This chapter, then, will describe the types and shapes of reinforcing steel commonly used by Steelworkers, the purpose of reinforcing steel in construction work, and the techniques and tools used by Steelworkers to bend, place, and tie reinforcing steel. The chapter also provides information on some of the duties which the Steelworker may perform as a crew leader of Steelworker team/work crews.

PURPOSE AND TYPES OF REINFORCING STEEL

The term "reinforced concrete" refers to concrete containing steel as reinforcement, and designed on the assumption that both materials act together in resisting force. Reinforcing steel is used in various types of concrete construction, such as retaining walls, foundation walls, beams, floor slabs, and footings. However, in certain types of construction, such as some pavements and floors, reinforcing steel may not be required.

Concrete is strong in compression but weak in tension. The tensile strength is generally rated about 10 percent of the compression. Thus, concrete works well for columns and posts which are the compression members in a structure. But, when it is used for tension members—for beams, girders, foundation walls, or floors—concrete must be reinforced to attain the necessary strength in tension.

Steel is the best material for reinforcing concrete because the coefficients of expansion of both the steel and the concrete are considered almost the same. That is, at a normal temperature, they will expand and contract at an almost equal rate. (At very high temperatures, steel will expand more rapidly than the concrete and the two materials will separate.)

Steel also works well as a reinforcement for concrete because it makes a good bond with the concrete. This bond strength is proportional to the contact area surface of the steel to the concrete. In other words, the greater the surface of steel exposed to the adherence of the concrete, the stronger the bond. A deformed reinforcing bar is better than a plain round or square one. In fact, when plain bars of a given diameter, approximately 40% more plain bars must be used.

Also, the rougher the steel surface, the better the adherence of the concrete. Thus, steel with a light, firm layer of rust is superior to clean steel, but steel with loose or scaly rust is inferior. Loose or scaly rust may be removed from the steel by rubbing the steel with burlap.

The requirements for reinforcing steel are that it be strong in tension and, at the same time, ductile enough to be shaped or bent cold.

Steel for reinforcing rods comes in three classes—mild, medium, and high carbon steel. The most common type in use is the medium grade because it is ductile enough to be bent cold and also is fairly hard, with more tensile strength than mild carbon steel. Steel that is very high in carbon is so hard that it is almost impossible to bend it cold without breaking it. In some cases the greater ductility of the mild carbon steel is an asset, and in others the greater strength of high carbon steel is desirable.

Reinforcing steel may be used in the form of bars, or rods, which are either plain or deformed, or in the form of expanded metal, wire, wire fabric, or sheet metal. Each type is useful for a different purpose, and engineers design structures with these purposes in mind.

Plain bars are usually round in cross-section. They are used as main tension reinforcement for concrete structures. They are the least used of the rod-type reinforcement because they offer only smooth even surfaces for the adherence

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of concrete. By the way, reinforcing bars or rods are commonly referred to as rebars.

Deformed bars are like the plain bars except that they have either indentations in them or ridges on them, or both, in a regular pattern. The twisted bar, for example, is made by twisting a plain square bar cold. The spiral ridges along the surface of the deformed bar increase its bond strength with concrete. Other forms used are the round and square corrugated bars. These bars are formed with projections around the surface which extend into the surrounding concrete and prevent slippage. Another type is formed with longitudinal fins projecting from the surface to prevent twisting. Figure 18-1 shows a few of the various types of deformed bars available. In the United States, deformed bars are used almost exclusively, while in Europe, both deformed and plain bars are used.

There are 10 standard sizes of reinforcing bars. Table 18-1 lists the bar number, weight, and nominal diameter of the 10 standard sizes. Bar #3 through #11, inclusive, are deformed bars. Remember that bar numbers are based on the nearest number of 1/8 inches included in the nominal diameter of the bar. To measure rebar, you must measure across the round/square portion where there is no deformation. The raised portion of the deformation is not considered when measuring the rebar diameter.

Expanded metal or wire mesh is also used for reinforcing concrete. Expanded metal is made by partly shearing a sheet of steel as shown in view A, figure 18-2. The sheet steel has been sheared in parallel lines and then pulled out or expanded to form a diamond shape between each parallel cut. Another type is square rather

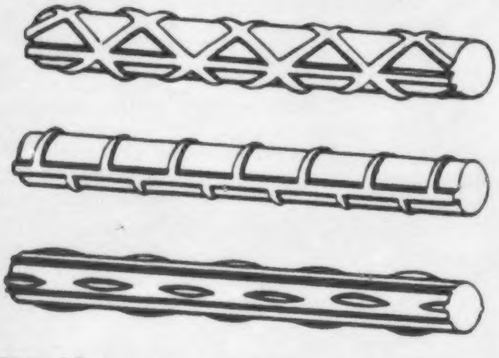


Figure 18-1.—Types of deformed reinforcing bars. 29.182

Table 18-1.—Standard Reinforcing Bars 127.167

Bar Numbers	Weight (Pounds Per Foot)	Nominal Dia. Diameter (Inches)
#2	.167	.250
#3	.376	.375
#4	.668	.500
#5	1.043	.625
#6	1.502	.750
#7	2.044	.875
#8	2.670	1.000
#9	3.400	1.128
#10	4.303	1.270
#11	5.313	1.410

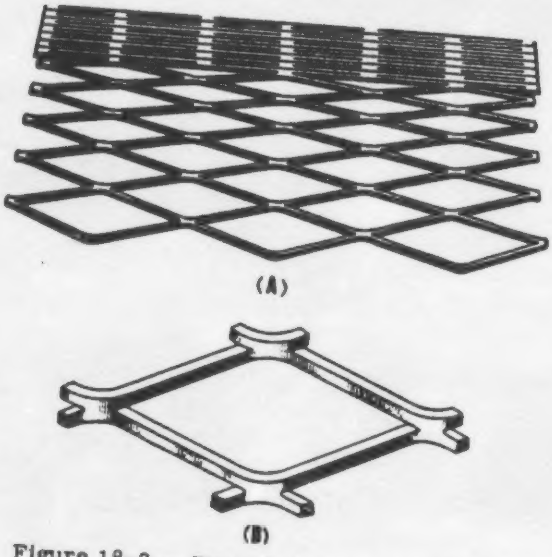


Figure 18-2.—Expanded or diamond mesh steel reinforcement. 127.74

than diamond shaped, as shown in view B, figure 18-2. Expanded metal is frequently used during plastering operations. Wire mesh of the welded wire fabric type is more often used for concrete footings and slabs.

Four figures are used to designate the style of wire mesh; for example, 6 x 6 - 8/8 (sometimes written 6 x 6 x 8 x 8). The first figure (in this case, 6) indicates the lengthwise spacing of the wire in inches; the second figure (6 in this case) indicates the crosswise spacing of the wire in inches; and the last two figures (8/8) indicate the size of the wire on the Washburn and Moen gage.

Sheet metal reinforcement is used mainly in floor slabs and in stair and roof construction. It consists of annealed sheet steel bent into grooves, or corrugations, about 1/16 inch in depth, with holes punched at regular intervals.

Wire is often used for joining reinforcement rods together. A few wraps around the rods with 16-gage soft-annealed iron wire will hold the rods in place. Thick wires are used as circular reinforcement in columns, tanks, and pipes. Woven wire is used mostly in light slabs and walls.

Wire fabric is made by weaving or welding wire or rods together to form rectangular or triangular shapes. These shapes are usually designed with main or load carrying wires and transverse or spacing wires. The carrying or load wires act as the reinforcment and the spacing wires complete the pattern and hold the main wires in place. This type of reinforcement is used largely for light walls, roofs, and floors.

BENDING REINFORCING BARS

The job of bending reinforcing bars will be quite interesting if you have some basic knowledge as to why bending is necessary. There are several reasons. First, let us go back to the reason for using reinforcing steel in concrete—the tensile strength and compressive strength of concrete. You might compare the hidden action within a beam from live and dead loads to the breaking of a scantling with your knee. You've seen how the splinters next to your knee push toward the middle of the scantling when you apply force, while the splinters from the middle to the opposite side pull away from the middle. Well, this is similar to what happens inside the beam.

For instance, take a simple beam (a beam resting freely on two supports near its ends). The dead load (weight of the beam) causes the beam to bend or sag. Now, from the center of the beam to the bottom, the forces tend to stretch or lengthen the bottom portion of the beam. This part is said to be in tension, and that is where the steel reinforcing bars are needed. As a result of the combination of the concrete and steel, the tensile strength in the beam resists the force of the load and keeps the beam from breaking apart. At the exact center of the beam, between the compressive stress and the tensile stress, there is no stress at all—it's neutral.

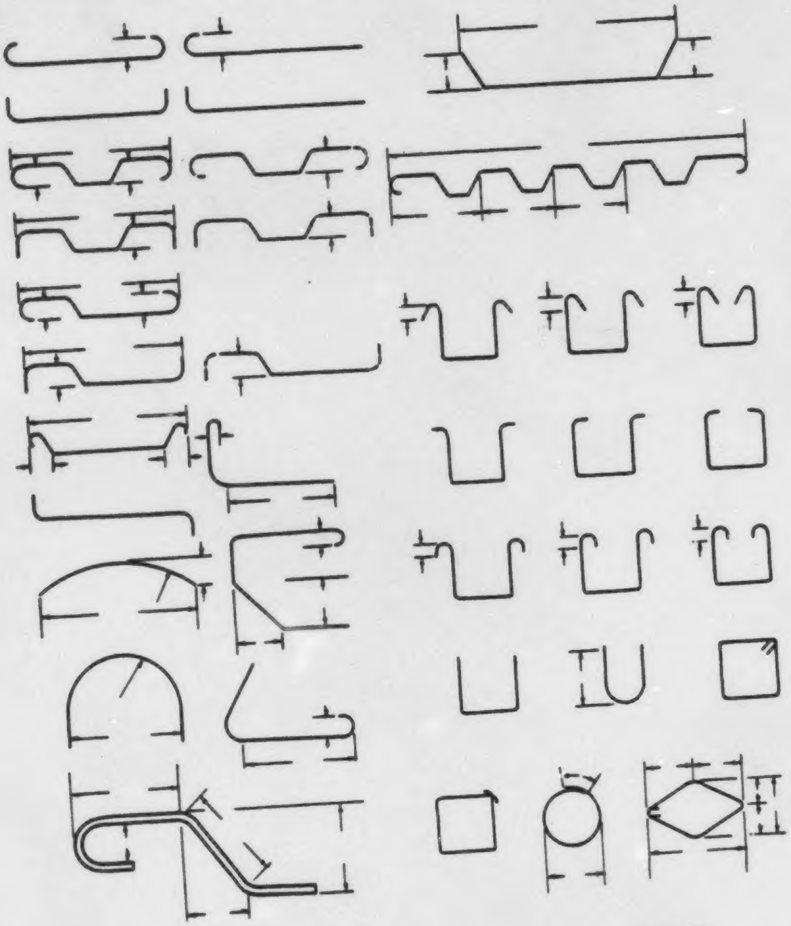
In the case of a continuous beam, it's a little different. The top of the beam may be in compression along part of its length and in tension along another part. This is because a continuous beam rests on more than two supports. Thus the bending of the beam is not all in one direction, but is reversed as it goes over intermediate supports.

To help the concrete resist these stresses, engineers design the bends of reinforcing steel so that the steel will set into the concrete just where the tensile stresses take place. That's why you may have to bend some reinforcing rods in an almost zigzag pattern. The joining of each bar with the next, the anchoring of the bar ends within concrete, and the anchoring by overlapping two bar ends together are some of the important ways to increase and keep bond strength. Some of the bends which you will be required to make in reinforcing bars are shown in figure 18-3.

The drawings for a job will provide all the information necessary for cutting and bending reinforcing bars. Reinforcing steel may be cut to size with shears or with an oxyacetylene cutting torch. The cutting torch is normally used in the field.

Before you start bending the reinforcing bars, you should check them and sort them at the job site. Only after you check the bars will you be sure that you have all you need for the job. Follow the construction drawings when you sort the bars, so that they will be in proper order to be bent and placed in the concrete forms. After you have divided the different sizes into piles, label each pile so that you and your crew can find them easily. The symbols for reinforced concrete construction are given in Structural Symbols, MIL-STD-18A.

For the job of bending, a number of types of benders may be used. Stirrups and column ties are normally less than #4 bar and you can



127.75

Figure 18-3.—Typical reinforcement bar bends.

bend them cold by means of the bending table shown in figure 18-4. Typical stirrup and column tie shapes are shown in figure 18-5. Stirrups are used in beams as illustrated in figure 18-6. Column ties are shown in position in figure 18-7.

Whenever possible, bend steel bars larger than #3 bar on a bar-bending machine. The steel should be cold when you bend it. Heating is normally not necessary except for #9 bars and larger. If you have a hydraulic reinforcement bar bender like that shown in figure 18-8, it can be used to bend bars cold up to a 2-inch diameter.

A hickey, like the one illustrated in figure 18-9, is an effective tool for bending bars, when the bars have to be bent in place. By placing the jaws of the hickey on one side of the center of the bend, and pulling on the handle, it is possible to produce a smooth, circular bend through almost any angle that is desired.

Make bends, except those for hooks, around pins with a diameter of not less than six times the bar diameter. If the bar is 1 inch or larger, the minimum pin diameter should be eight times the bar size.

To get smooth sharp bends when bending large rods, slip a pipe cheater over the rod. This piece of pipe gives you a better hold on the rod itself, and makes the whole operation smoother. You can heat #9 bars and larger to a cherry red before bending them, but make

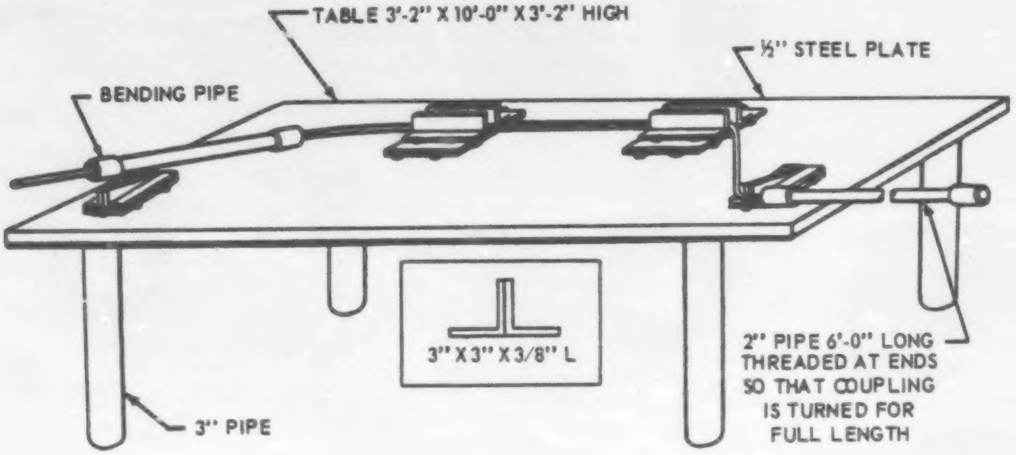
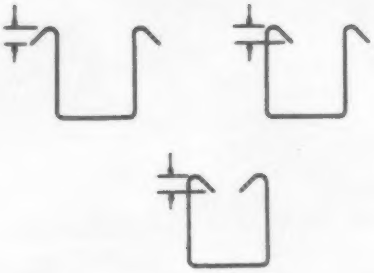


TABLE 3'-2" X 10'-0" X 3'-2" HIGH
½" STEEL PLATE
BENDING PIPE
3" X 3" X 3/8" L
2" PIPE 6'-0" LONG THREADED AT ENDS SO THAT COUPLING IS TURNED FOR FULL LENGTH
3" PIPE

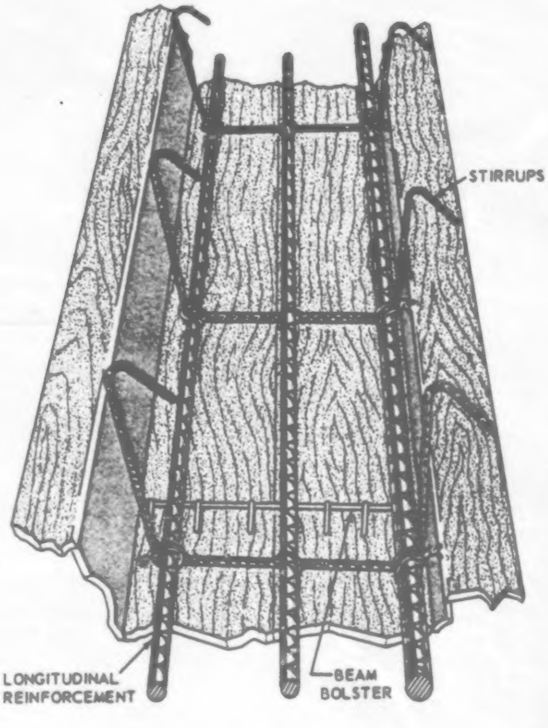
127.76
Figure 18-4.—Bar-bending table.



127.77
Figure 18-5.—Stirrup and column ties.

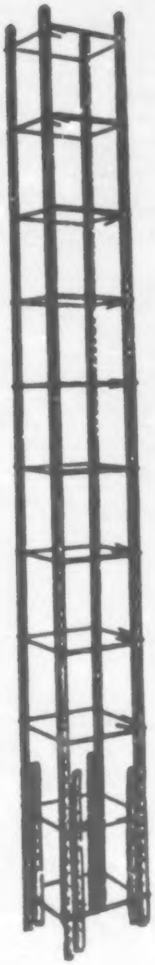
sure you don't get them any hotter. If the steel becomes too hot, it will lose strength, become brittle, and may even crack.

If you don't want your rod to crack while it is being bent, bend it gradually, not with a jerk. Don't make your bends too sharp. Bends made on a bar-bending table or block are usually too sharp and the bar is somewhat weakened. Certain minimum bend diameters have, therefore, been established for the different bar sizes and for the various types of hooks. These bending details are shown in figure 18-10. You'll find there are many different types of bends to make, depending on where the rods are to be placed. For example, there are bends on heavy beam and girder bars, bends for reinforcement of

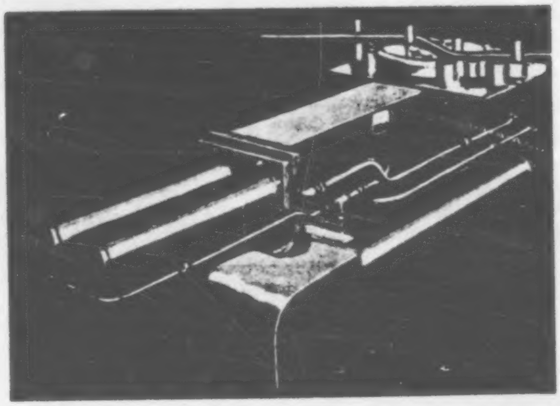

STIRRUPS
LONGITUDINAL REINFORCEMENT
BEAM BOLSTER

45.481
Figure 18-6.—Steel in place in a beam.

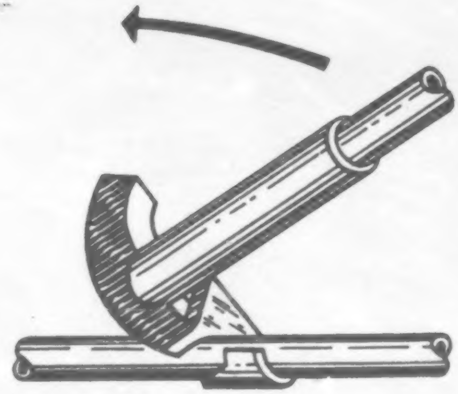
218



45.482A
Figure 18-7.—Column steel in place.



29.183
Figure 18-8.—A 2-inch capacity automatic reinforcement bar bender.



127.78
Figure 18-9.—Hickey.

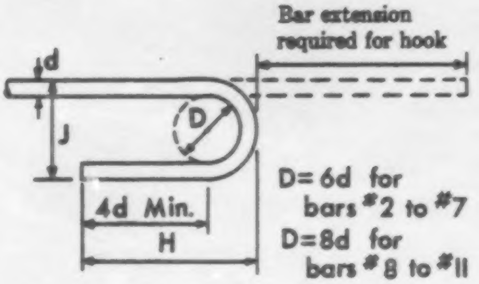
vertical columns at or near floor levels, stirrups and column ties, slab reinforcement, and bars or wire for column spiral reinforcement. To save yourself some time and extra work, try to make all bends of one kind at one time, instead of remeasuring and resetting templates on your bending block for different bends.

PLACING AND TYING REINFORCING STEEL

Before placing reinforcing steel in forms, all form oiling should be completed. Oil on reinforcing bars is objectionable because it reduces the bond between the bars and the concrete. Use a piece of burlap to clean the bars of rust, scale, grease, mud, or other foreign matter. A tight film of rust or mill scale is not objectionable.

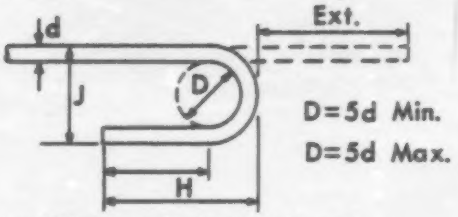
Bars are marked to show where they will fit. You may work according to either one of the two most-used systems for marking bars. Whichever system is used, it ought to agree with the marking system which appears on the engineering or assembly drawings. In one system, all of the bars in one type of member are given the mark of that member. With this system,

Recommended sizes—180° hook


Bar extension
required for hook
d
D
J
4d Min.
H
D= 6d for
bars #2 to #7
D=8d for
bars #8 to #11

Bar size d	Bar exten.	J	Approx. H
#2	4	2	3½
3	5	3	4
4	6	4	4½
5	7	5	5
6	8	6	6
7	10	7	7
8	13	10	9
9	15	11¼	10¼
10	17	12½	11¼
11	19	14	12¾

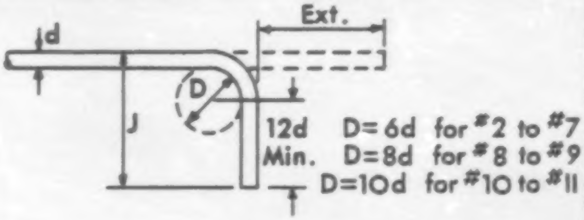
Minimum sizes—180° hook


Ext.
d
D
J
H
D=5d Min.
D=5d Max.

Note: Minimum size hooks to be used only for special conditions. Do not use for hard-grade steel.

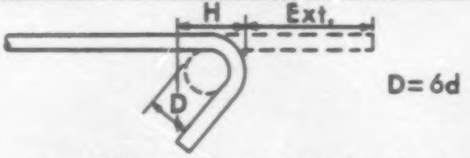
Bar size d	Bar exten.	J	Approx. H
#2	4	1¾	3½
3	5	2¾	4
4	5	3½	4¼
5	6	4¼	4¾
6	7	5¼	5¾
7	9	6	6½
8	10	7	7½
9	11	8	8½
10	13	9	9½
11	14	10	10½

Recommended minimum sizes—90° hook


Ext.
d
D
J
12d
Min.
D= 6d for #2 to #7
D= 8d for #8 to #9
D=10d for #10 to #11

Bar size d	Bar exten.	Approx. J
#2	3½	4
3	5½	6
4	7½	8½
5	9	10½
6	10½	1-0½
7	1—0½	1-2½
8	1-2½	1-5
9	1-4½	1- 7
10	1-6½	1-11
11	1-8½	2- 1½

Recommended sizes—135° stirrup hook



Bar size d	Bar exten.	H
#2	3½	2¼
3	4	2½
4	4½	3
5	5½	3¾

Note: Stirrup hooks may be bent to the diameter of the supporting bars.

127.79
Figure 18-10.—Standard hook details.

there are column bars, beam bars, footing bars, and so on.

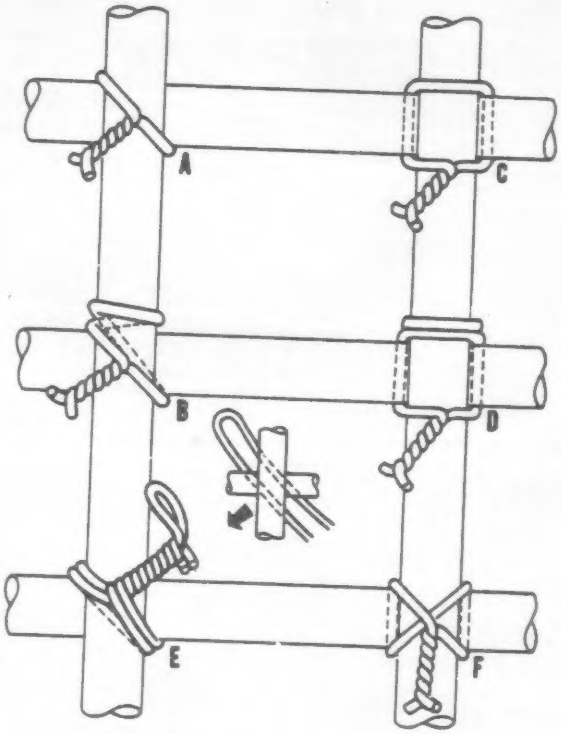
In the other system the bars are marked in greater detail. These marks show exactly where the bar is to be placed. In addition to the type member (e.g. beam (B), wall (W), column (C), and so on), the marks show which floor the bars are to be placed on, and the size and individual number of each particular bar. Instead of showing the bar size by its diameter measurement, the mark shows the bar size in code, by eighths. The examples shown below illustrate the second type of marking system.

2B805
- 2 = second floor
- B = beam member
- 8 = 8/8 or 1 inch, square bar
- 5 = part of the second floor plan designated by the number 5

2B0605
- 2 = second floor
- B = beam member
- 06 = 6/8 or 3/4 inches, round bar
- 5 = part of second floor plan designated by the number 5

Tie wire is used to hold rebar in place so that when concrete is placed the bars will not shift out of position. As mentioned earlier, 16-gage wire is used to tie reinforcing bars. About 12 pounds of wire is required to tie an average ton of bars. Incidentally, tie wire adds nothing to the strength of the steel.

A number of different types of ties can be used with reinforcing bars; some are more effective than others. Figure 18-11 illustrates six types of ties, which are identified below according to letters of the alphabet used to show individual ties.



127.80
Figure 18-11.—Types of ties.

A. SNAP TIE or SIMPLE TIE. The wire is simply wrapped once around the two crossing bars in a diagonal manner with the two ends on top, and these are twisted together with a pair of sidecutters until they are very tight against the bars. Then the loose ends of the wire are cut off. This tie is used mostly on floor slabs.

B. WALL TIE. This tie is made by going about one and a half times around the vertical bar, then diagonally around the intersection, twisting the two ends together until the connection is right, but without breaking the tie wire, then cutting off the excess. The wall tie is used on light vertical mats of steel.

C. SADDLE TIE. The wires pass halfway around one of the bars on either side of the crossing bar and are brought squarely or diagonally around the crossing bar, with the ends twisted together and cut off. This tie is used on special location (walls).

D. SADDLE TIE WITH TWIST. This tie is a variation of the saddle tie. The tie wire is carried completely around one of the bars, then squarely across and halfway around the other, either side of the crossing bars, and finally brought together and twisted either squarely or diagonally across. The saddle tie with twist is used for heavy mats that are to be lifted by crane.

E. DOUBLE STRAND SINGLE TIE. This tie is a variation of the simple tie. It is used in some localities, and is especially favored for heavy work.

F. CROSS TIE or FIGURE-EIGHT TIE. This type of tie has the advantage of causing little or no twist in the bars.

When you are tying reinforcing bars you must have a supply of tie wire available. There are several ways you can carry your tie wire. One way is to coil it to a diameter of 18 inches, then slip it around your neck and under one arm as shown in figure 18-12, view A. This leaves a free end for tying. Coil enough wire so it weight about 9 pounds.

Another way to carry tie wire is in an automatic coiler. You can suspend the coiler from your belt as shown in figure 18-12, view B; the coiler shown holds about a pound of tie wire.

Still another way to carry tie wire is to take pieces of wire about 9 inches long, fold them and hook one end in your belt; then you can pull the wires out as needed.

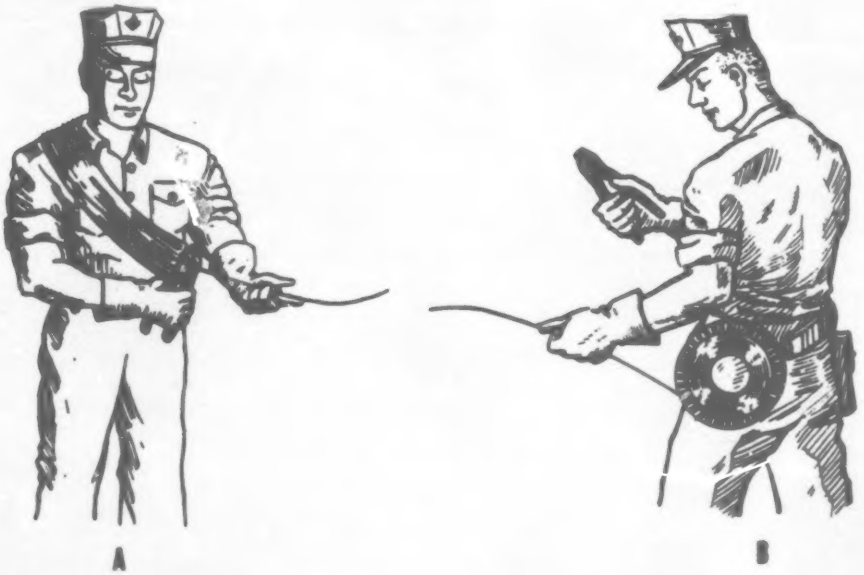
You may at times receive tie wires of appropriate length with a loop in each end. A versatile tool used to pull the loop tight is the automatic twister shown in view A, figure 18-13. The twister functions basically on the same principle as the yankee screwdriver, except that the twister is pulled as shown in view B, figure 18-13.

Other tools used in typing reinforcing bars include sidecutters; leather gloves; 50-foot tape measure; and keel crayon, either yellow, red, or blue.

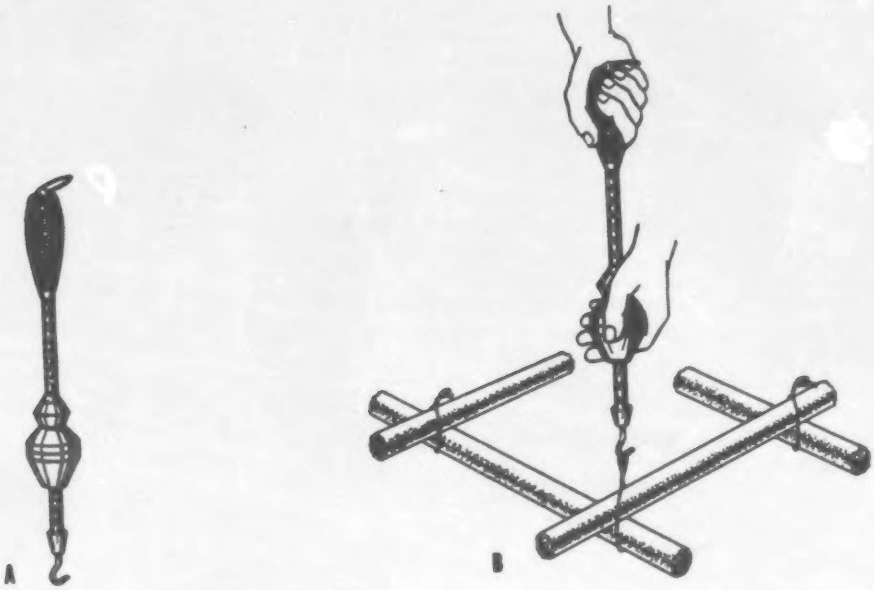
The proper location for the reinforcing bars is usually given on drawings. In order for the structure to withstand the loads it must carry, place the steel in the position shown. Secure the bars in position in such a way that concrete placing operations will not move them. This can be accomplished by the use of the reinforcing bar supports shown in figures 18-14, 18-15, and 18-16.

Footings and other principal structural members which are against the ground should have at least 3 inches of concrete between steel and ground. If the concrete surface is to be in contact with the ground or exposed to the weather after removal of the forms, the protective covering of concrete over the steel should be 2 inches. It may be reduced to 1 1/2 inches for beams and columns, and 3/4 inch for slabs and interior wall surfaces, but it should be 2 inches for all exterior wall surfaces. This measurement, incidentally, is taken from the main rebar, not the stirrups or ties.

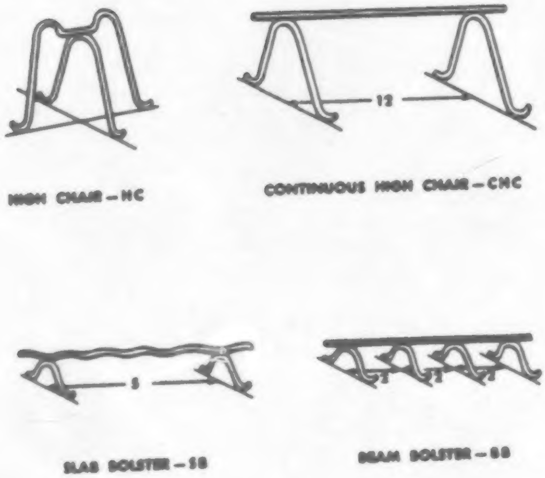
Where splices in reinforcing steel are not dimensioned on the drawings, the bars should



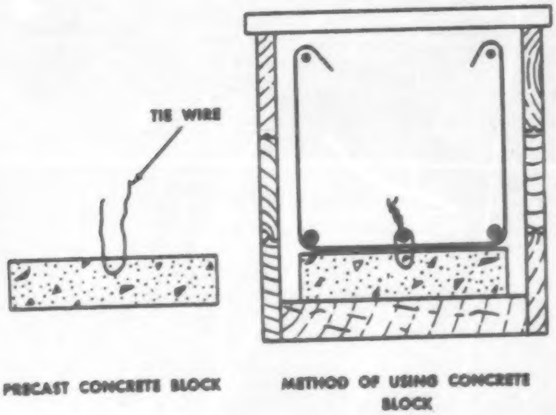
127.81
Figure 18-12.—Carrying tie wire.



127.82
Figure 18-13.—Twister.


12
HIGH CHAIR — HC
CONTINUOUS HIGH CHAIR — CHC
5
SLAB BOLSTER — SB
BEAM BOLSTER — BB

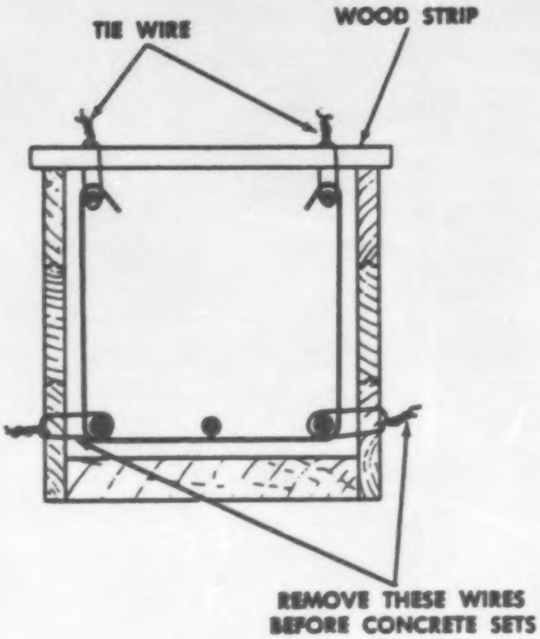
45.480
Figure 18-14.—Steel accessories.


TIE WIRE
PRECAST CONCRETE BLOCK
METHOD OF USING CONCRETE BLOCK

127.83
Figure 18-15.—Precast concrete block used for reinforcing steel support.

be lapped not less than 30 times the bar diameter, nor less than 12 inches.

To lap wire mesh, a number of methods are used, two of which are: the end lap and the side lap.

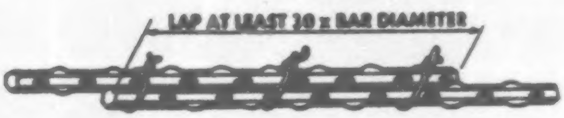


127.84
Figure 18-16.—Reinforcing steel hung in place.

In the end lap method, the wire mesh is lapped by overlapping one full mesh measured from the end of longitudinal wires in one piece to the end of longitudinal wires in the adjacent piece, and then tying the two pieces at 1' 6" centers with a snap tie.

In the side lap method, the two longitudinal side wires are placed one alongside and overlapping the other, and then are tied with a snap tie every 3 feet.

The stress in a tension bar can be transmitted through the concrete and into another adjoining bar by a lap splice of proper length. The lap is expressed as the number of bar diameters. If the bar is #2 make the lap at least 12 inches. Tie the bars together with a snap tie as shown in figure 18-17.



127.85
Figure 18-17.—Bars spliced by lapping.

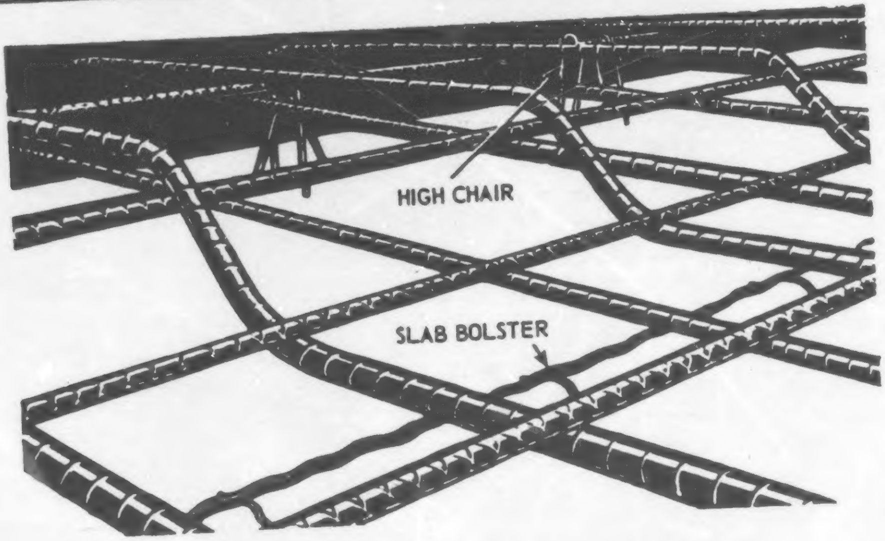
The bars can also be spliced by metal arc welding. For bars which are placed in a vertical position, a butt weld is preferred. The end of the bottom bar is cut square, and the end of the top bar resting on it is cut in a bevel fashion, thus permitting a butt weld. For bars which will bear a load in a horizontal position, a fillet weld is preferred. Usually the two bars are placed end to end (rather than overlapping) and pieces of flat bar (or angle iron) are placed on either side. Fillet welds are then made where the metals join. The welds are made to a depth of one-half the bar diameter and for a length eight times the bar diameter.

The minimum clear distance between parallel bars in beams, footings, walls, and floor slabs should either be 1 inch, or 1 1/3 times the largest size aggregate particle in the concrete, whichever distance is greater. In columns, the clear distance between parallel bars should always be not less than 1 1/2 times the bar diameter, or 1 1/2 times the maximum size of the coarse aggregate, always using the larger of the two.

The support for reinforcing steel in floor slabs is shown in figure 18-18. The height of the slab bolster is determined by the concrete protective cover required. Concrete blocks made of sand-cement mortar can be used in place of the slab bolster. Wood blocks should never be used for this purpose if there is any possibility that the concrete can become wet and if the construction is of a permanent type. Bar chairs of a type shown in figure 18-18 can be obtained in heights up to 6 inches. If a height greater than this is required, make the chair of No. 0, soft, annealed iron wire. Tie the bars together at frequent intervals with a snap tie where they cross to hold the bars firmly in position.

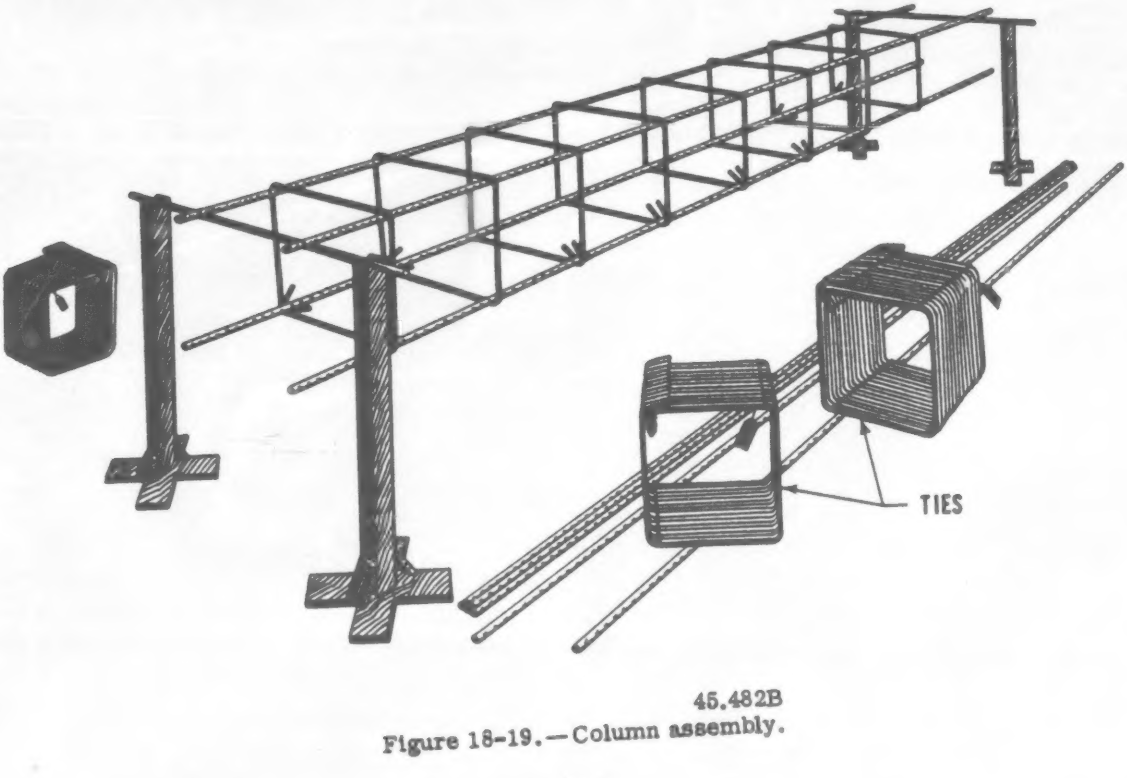
Steel for column ties may be assembled with the verticals into cages, by laying the veritcal bars for one side of the column horizontally across a couple of sawhorses. The proper number of ties are slipped over the bars, the remaining vertical bars are added, and then the ties are spaced out as required by the placing plans. All intersections are wired together to make the assembly rigid, so that it may be hoisted and set as a unit. Figure 18-19 shows a typical column tie assembly.

After the column is raised it is tied to the dowels or reinforcing steel carried up from below. This holds it firmly in position at the base. The column form is erected and the reinforcing


HIGH CHAIR
SLAB BOLSTER

127.86

Figure 18-18.—Steel in place in a floor slab.



45.482B

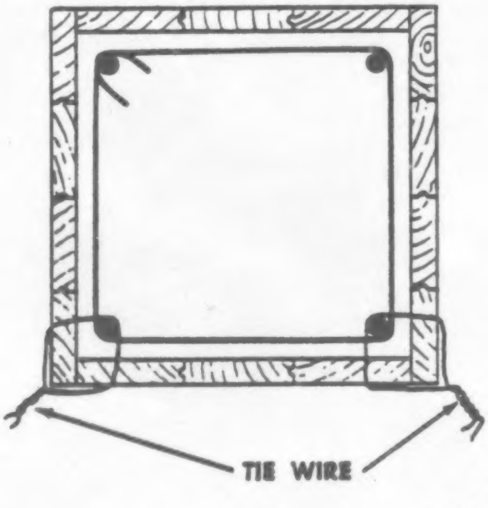
Figure 18-19.—Column assembly.

steel is tied to the column form at 5-foot intervals, as shown in figure 18-20.

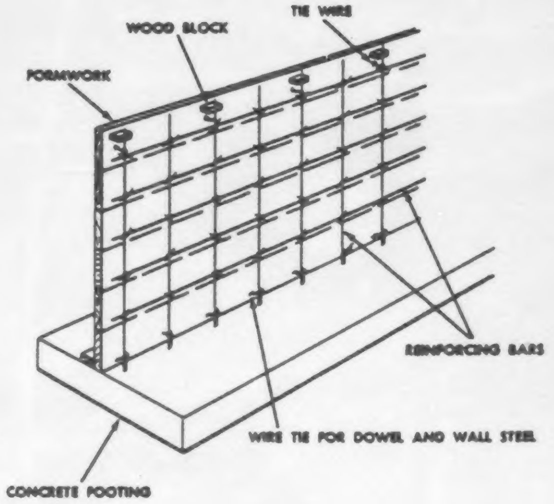
The use of metal supports to hold beam reinforcing steel in position is shown in figure 18-6. Note the position of the beam bolster. The stirrups are tied to the main reinforcing steel with a snap tie. Wherever possible you should assemble the stirrups and main reinforcing steel outside the form and then place the assembled unit in position. Wood blocks should be substituted for the metal supports only if there is no possibility of the concrete becoming wet or if the construction is known to be temporary. Precast concrete blocks, as shown in figure 18-15, may be substituted for metal supports or, if none of the types of bar supports described above seems suitable, the method shown in figure 18-16 may be used.

Placement of steel in walls is the same as for columns except that the steel is erected in place and not preassembled. Horizontal steel is tied to vertical steel at least three times in any bar length. Steel in place in a wall is shown in figure 18-21. The wood block is removed when the form has been filled up to the level of the block. For high walls, ties in between the top and bottom should be used.

Steel is placed in footings very much as it is placed in floor slabs. Stones, rather than steel supports, may be used to support the steel at the proper distance above the subgrade. Steel mats in small footings are generally preassembled and placed after the forms have been set. A typical arrangement is shown in figure 18-22. Steel mats in large footings are constructed in place.



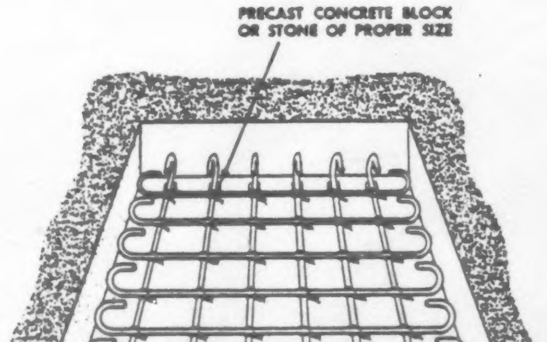
127.87
Figure 18-20.—Method for holding column steel in place.



127.88
Figure 18-21.—Steel in place in a wall.

HANDLING AND STORING OF REINFORCING BARS

Special care should be exercised in the handling and storing of reinforcing steel. Some



127.89
Figure 18-22.—Steel in place in a footing.

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of the safety precautions to be observed are listed below.

When unloading incoming bundles of reinforcing bars from a truck, see that both ends leave the truck at the same time. If pushed off the truck, the end of the bundle that leaves the truck last has a tendency to WHIP UP, and this can cause serious injury to the man on the truck.

Stand clear several feet from any bundle of reinforcing bars leaving a truck.

When two men carry lengths of reinforcing steel, both should release the load at exactly the same time to avoid a serious fracture or injury.

When lifting heavy loads, remember to flex the knees in a stooping position to avoid straining.

Wear leather gloves and other suitable clothing when handling reinforcing steel. Avoid unnecessary belts or pockets which could become caught on projecting objects.

Never raise bundles of reinforcing steel by the bundle wire. Use a wire rope sling. Wrap the sling completely around the bundle of bars, on the center of the bundle, and make sure you attach the sling so that it will tighten itself. By attaching the sling in this manner, the rods cannot slip out of the bundle nor twist within the bundle.

Reinforcing bars should be stored so that excessive rusting or coating by grease, oil, dirt, and other objectionable materials will be avoided. All rebar stored on the ground must be on dunnage to keep it out of the mud. Storage should be in separate piles or racks so as to avoid confusion or loss of identification after bundles are broken.

Incoming stocks of reinforcing bars are stored according to size or bar number; for instance, all #2 bars in one pile, #3 bars in a separate pile, and so on.

In a reinforcing steel bending shop, racks often may be used for storing rods that have been bent. When this is done, it is important to designate and label each rack according to the size of rod to be stored in it.

ASSIGNMENT AS CREW LEADER

The SW who wants to get ahead can expect to be called upon to assume more responsible duties as he gains experience in steelworking operations. These heavier responsibilities will probably include the assignment as crew leader or SW work/crews consisting of 3 to 5 men. A team/work crew may perform various types of work—such as place and tie reinforcing steel, erect prefabricated buildings, or assemble pontoon structures. Your duties as a crew leader may vary from one activity to another. At most activities, however, a crew leader's duties may involve planning work assignments, preparing requisitions, and keeping time cards. Information that will aid you in carrying out these duties is given below.

PLANNING WORK ASSIGNMENTS

The planning of day-to-day work assignments for team/work crews can be a difficult job unless the crew leader is familiar with the capabilities of his men and equipment needed to complete the work projects assigned. This is particularly true in a combat zone where the priorities of construction may be subject to change daily. You may have your best team/work crew on a prefabricated steel erection project, when suddenly an emergency job comes up that requires some of your team/work crew members plus a number of pieces of your equipment to be dispatched to another jobsite. Since the original erection project must continue, you must be able to re-organize and assign team/work crew members so that work on the erection project can continue. By knowing your crews and their capabilities you should be able to control the project and:

1. Plan work to avoid wasted or poorly utilized manpower.

2. Be sure that each element in a project is really needed. Eliminate or combine operations.

3. Arrange priorities of projects and have second or third priorities ready so that crews can shift work if delayed on a primary project.

4. Make sure tools, supplies, and materials are on hand.

5. When necessary, determine types of manpower required for different elements within a project.

6. Establish rates of work. How many hours should a particular job take under normal conditions? and under adverse conditions?